

**STANDARDIZATION OF SEED GERMINATION
TESTING PROCEDURE IN SARPGANDHA
(*Rauvolfia serpentina Benth.*)**

By

Mr. BUDHABHUSHAN RENURAO MUNESHWAR
(Reg. No. R/013/048)

A Thesis Submitted to the

**MAHATMA PHULE KRISHI VIDYAPEETH
RAHURI - 413 722, DIST.AHMEDNAGAR
MAHARASHTRA, INDIA**

In partial fulfilment of the requirements for the degree

of

MASTER OF SCIENCE (AGRICULTURE)

in

**AGRICULTURAL BOTANY
(SEED SCIENCE & TECHNOLOGY)**

DEPARTMENT OF AGRICULTURAL BOTANY

**POST GRADUATE INSTITUTE
MAHATMA PHULE KRISHI VIDYAPEETH
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MAHARASHTRA, INDIA**

2015

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MAHATMA PHULE KRISHI VIDYAPEETH
RAHURI - 413 722
2015**

CANDIDATE'S DECLARATION

I hereby declare that this thesis or a part
there of has not been submitted
by me or any other person
to any other University
or Institute for
a Degree or
Diploma.

Place: MPKV, Rahuri

Date: / / 2015

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Maharashtra State.

CERTIFICATE

This is to certify that the thesis entitled, “**STANDARDIZATION OF SEED GERMINATION TESTING PROCEDURE IN SARPGANDHA (*Rauvolfia serpentine Benth.*)**”, submitted to the Faculty of Agriculture, Mahatma Phule Krishi Vidyapeeth, Rahuri, Dist. Ahmednagar (Maharashtra State) in partial fulfilment of the requirements for the degree of **MASTER OF SCIENCE (AGRICULTURE) in SEED SCIENCE & TECHNOLOGY**, embodies the results of a piece of *bona fide* research work carried out by **Mr. MUNESHWAR BUDHABHUSHAN RENURAO**, under my guidance and supervision and that no part of the thesis has been submitted for any other Degree or Diploma.

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LIST OF ABBREVIATION

%	: Per cent
/	: Per
@	: At the rate
°C	: Degree Celsius
A.D.	: Anno Domini (After Christ)
B.C.	: Before Christ
C.D.	: Critical differences
cm	: centimeter
DAS	: Days after storage
DMC	: Dry matter content
dSm ⁻¹	: Desi Simen per meter
EC	: Electrical conductivity
et al	: And other (<i>et alli</i>)
GP	: Germination Percentage
hrs	: Hour
i.e.	: That is (<i>id est</i>)
kg	: Kilogram
mg	: Milligram
ml	: Mililitre
NS	: Non-Significant
SE	: Standard error
Viz.,	: Namely (<i>videlicent</i>)

ABSTRACT

**“STANDARDIZATION OF SEED GERMINATION
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A candidate for the degree

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MASTER OF SCIENCE (AGRICULTURE)

in

SEED SCIENCE & TECHNOLOGY**2015**

Research Guide : Dr. V. R. Shelar**Department : Agril. Botany**

The present investigation was undertaken to standardize the seed germination testing procedure of sarpgandha (*Rauvolfia serpentina* Benth). The experiment was conducted during 2014-2015 at Seed Technology Research Unit (STRU), M.P.K.V., Rahuri. The fresh seeds were collected from Medicinal and Aromatic Plants Project ('Dhanwantari Garden'), M.P.K.V. Rahuri. The experiment was conducted in Factorial Completely Randomized Design (FCRD) to assess the suitable method, temperature and treatment for germination testing methods of sarpgandha.

The sarpghandha seeds were treated with different treatments i.e. chemicals *viz.*, conc. H₂SO₄ for 3 min. (T₂), con.H₂SO₄ for 5 min. (T₃) and conc. H₂SO₄ for 10 min. (T₄), 1% KH₂PO₄ for 24 hrs. (T₅), 1% KNO₃ for 24 hrs. (T₆), 2% KNO₃ for 24 hrs. (T₇), 0.5% Thiourea for 5 min. (T₈) and Cow urine for 5 min. (T₉) and physical *viz.*, mechanical scarification with sand paper (T₁₀), cold stratification for 24 hrs. (T₁₁), water soaking for 24 hrs. (T₁₂), along with control i.e. untreated seeds (T₁) were used for experiments.

For standardization of seed germination testing procedure four germination methods *viz.*, between paper method (M₁), sand method (M₂), top of paper method (M₃) and cocopeat method and three temperatures *viz.*, 20 ± 2 °C (C₁), 25 ± 2 °C (C₂) and 30 ± 2 °C (C₃) were used. The seed quality attributes *viz.*, germination (%), root length (cm), shoot length (cm), dry matter content of seedling (mg), vigour index-I, vigour index-II, seed mycoflora (%), moisture content (%), electrical conductivity (dsm⁻¹), and seed weight (g) was recorded.

Among the seed treatments the seed treated with 2% KNO₃ for 24 hrs gave significantly higher germination (38.75 %) in sarpghandha as compared to control (18.08 %). The root and shoot length was also significantly higher (3.66 and 7.77 cm) when treated with 2% KNO₃ for 24 hrs as compared with control (1.90 and 5.50 cm). Significantly higher dry matter weight (238.33 mg) was obtained when seed were treated with 2% KNO₃ for 24 hrs. The increase in vigour index I and II (383.92 and

9.44) were also observed with 2% KNO₃. Seed treated with 2% KNO₃ showed lower electrical conductivity (0.391 dsm⁻¹) as compared with control (0.529 dsm⁻¹). The 2% KNO₃ treated seed showed decrease in moisture content. The seed treated with conc. H₂SO₄ reported no mycelium growth. Seed weight decreases when seed treated with 2% KNO₃ as compared to control.

After standardization of seed germination procedure, the seed were kept for storage in high density polyethylene bag (HDEP) at room temperature. It was observed that germination was increased up to 120 days of storage. The germination was at its highest when seed was treated with 2% KNO₃ and kept in sand at 30 ± 2°C at 120 days of storage (70.00%). The root, shoot length seedling dry weight and vigour index was also increased up to 120 days when seed treated with 2% KNO₃ and kept in sand at 30 ± 2°C for germination. After 180 days, the germination was decreased and the same trend was observed for root, shoot length seedling dry weight and vigour index. The electric conductivity and seed mycoflora was increased as period of storage increased. The seed moisture content and seed weight was decreases with increasing in storage period. The seeds treated with 2% KNO₃ and kept in sand method at 30 ± 2 °C are the ideal condition for higher germination.

1. INTRODUCTION

Sarpagandha *Rauvolfia serpentine* L. Benth. (Family: Apocynaceae) is a woody perennial shrub, commonly known with different names, snake root plant, chotachand, chandrika etc. The roots of this shrub have been used for centuries in ayurvedic medicines. This shrub is highly effective in the treatment of high blood pressure. It is also very useful in mental disorders like insanity, mental illness and traumas. (Gupta *et al.*, 2005) It is equally effective in treating insomnia because of its sedative properties. It found useful for Hysteria and Urticaria. According to Ayurveda it is the best among all anti-hypertensive drugs. It has been stated that the drug is useful in mental disease, epilepsy, sleeplessness and several other ailment.

This is a genus of around one hundred species and five are native to India. These are herbacious or woody shrubs and glabrous. They attain a maximum height of 75 cm. Leaves are arranged in whorls of 3-4 up to 10 cm long and 5 cm broad, gradually tapering into a petiole. Leaves are bright green above and pale beneath. Flowers are white or pinkish, peduncle deep red, about 1.5 cm long, appear in small clusters. Fruit is drupe, polished green in young stage and purplish black at maturity. It is slightly connate and obliquely ovoid and is found in bunch depending upon height and healthiness of plant. The bark is pale brown and corky with irregular longitudinal fissures on it. Seeds have smooth but extremely hard seed coat surface.

This species is native to Bangladesh, Burma, Sri Lanka, Malaya, India and Indonesia. In India the plant is occurring in Sub-Himalayan tracts in Punjab, in lower ranges of Eastern and Western Ghats, Assam, Chhotanagpur, U.P, M.P, Orissa, Bihar, Maharashtra and Andaman islands (Gupta *et al.*, 1978).

The plant is medicinally important in the treatment of cardiovascular diseases, hypertension and various psychiatric diseases. Interestingly, its roots were long used in India for treating mental illness and snakebite, known to medicine man and peasants as the “Insanity herb” or “snake root” or “Sarpagandha”. The alkaloids are effective against snake bites and scorpion stings. The plant is reported to contain various iodole group alkaloids that are localized in the roots. More than 50 alkaloids have been reported from *R. serpentina*. The most important alkaloids isolated from the roots are reserpine, ajmaline, ajmalicine, ajmalinine, serpentina, alloyohimbine, chandrine, deserpidine, isoajmaline, yohimbine, isoyohimbine, and 11-methoxy-deltayohimbine. Dried root bark powder is used against insomnia, schizophrenia or violent mental disorders. Local tribes of Gadchiroli (Maharashtra) use *R. serpentine* root and leaves to treat snake bites. Its freshly ground leaves when applied to the toe serve as an antidote for snake poison. Some people of Mulchera Gadchiroli district (Maharashtra) think that snakes do not come closer around 20-25 ft. distance surrounding this plant.

It grows well in tropical to subtropical climate receiving heavy rains between June and August. The areas having more

equable climatic variations seem to be more suited than the areas having higher climatic variations. It prefers soil with plenty of humus and rich in nitrogenous and organic matter with good drainage. Alkaline soils are not suitable for commercial cultivation (Dey and De, 2010). The plant sheds its leaves during winter. In pharmaceutical industries, roots of *Rauwolfia* and its products are in great demand. Even though the chemical synthesis of reserpine is possible, it costs more than extracting it from natural resources.

Mass scale collection of this plant from natural habitats has lead to depletion of plant resources. The availability of *R. serpentine* has been decreased in the wild to the extent that it has been included under the category of endangered plants, and also included in the list of the items banned for export. There is an urgent need to conserve this important endangered medicinal plant. To meet the increasing demand of *R. serpentine* roots, we need a farmers friendly cultivation package by which good quality of roots should be obtained on sustainable basis. There is need to find out the most suitable method of cultivation in terms of root yield and alkaloid content. But due to rapid growth of world population, increasing anthropogenic activities, rapidly eroding natural ecosystem etc, the natural habitat of this important shrub *Rauwolfia* is dwindling. It is now an endangered species in India due to indiscriminate collection and over exploitation of natural resources for commercial purposes to meet the requirements of pharmaceutical industry, coupled with limited cultivation. The propagation of *R. serpentine* through

seeds is difficult due to less viability and very low germination percentage (Nayar 1956, Dutta *et al.*1962) Propagation by direct sowing of seeds in the field has not been found successful. Sun-dried and stored seeds generally give a low rate of germination and seeds stored more than 7 - 8 months practically did not germinate. The germination percentage of seed is very poor and variable (25 - 50 %) and is often as low as 10 % that is due to the presence of cinnamic acid derivatives

In view of the above, the present study entitled “Standardization of seed germination testing procedure in sarpgandha (*Rauvolfia serpentina*)” is undertaken with the following objective

1. Standardization of seed germination testing procedure of sarpgandha (*Rauvolfia serpentina*).

2. REVIEW OF LITERATURE

Many workers have attempted to study the presence of seed dormancy, its duration, and its mechanism, method to overcome it and standardize the germination methods of many plant species. The standard seed testing procedures including laboratory germination tests have also been prescribed in International Rules for seed testing for most of agricultural and horticultural crops. However, for most of the medicinal plants, the germination methods are either unknown or imprecisely known. Available literature relevant to present investigation entitled standardization of germination techniques in medicinal plants species have been reviewed in this chapter.

2.1 Effect of seed treatments

Hedayatullah (1959) revealed that seed germination of *R. serpentina* was quite erratic, ranged from 8-48% with an average of 19%. Thus, propagation through cuttings alone and or in maximum combination with hormone treatment may be helpful.

Gupta (1971) reported that dormancy of *Solanum melongena* seeds could be removed by application of IAA (10-20 ppm), NAA (10-40 ppm) and GA₃ (10-40 ppm).

Sharma and Chakraborty (1971) found that seeds of *Lactuca sativa* do not germinate and showed considerable amount of dormancy. It could be eliminated by application of GA₃ (50 mg/l) and Thiourea (1000 mg/l).

Tyagi and Sharma (1977) reported that treating of seeds of *solanum nigrum* treated with 0.2 % KNO₃ improved the

germination.

Joshua (1978) reported that pre-sowing seed treatment with GA₃ @ 500 ppm for 24 hrs at 25 °C temperatures for 6 days significantly increased the germination in *Solanum incanum*.

Dey and Choudhari (1982) treated the *Ocimum sanctum* seeds with hormones and promoters viz., 10 ppm of GA₃, 75 ppm of kinetin, 50 ppm of ethrel, 25 ppm of boric acid, 10 ppm of KNO₃ and one per cent of ascorbic acid. They reported that hormones and promoters were significantly improved the germination of seeds.

Bahuguna *et al.* (1987) reported that the highest germination in champa (*Michellia champaca*) was obtained at of 500 ppm GA₃ treatment but germination value was highest in 1000 ppm and it was slightly greater 24 hours of soaking of seeds than 48 hours.

Jones and Sanders (1987) reported that increased the rate of germination by soaking pepper seeds either in water or in KNO₃ + KH₂PO₄ solution for 10 hrs.

Mandal *et al.* (1987) reported that 80 and 82 per cent germination was observed in Coriander and Fennel seeds when seeds were soaked in water for 5 hrs and 10 hrs, respectively before sowing.

Veeraragavadatham *et al.* (1988) found that ipecac (*Cephalis ipecauanha*) seeds treated with 200 ppm of KH₂PO₄ solution for 24 hours exhibited maximum germination as compared to control.

Radhakrishnan *et al.* (1989) reported that seeds treated with KNO_3 promoted the germination of positively photoblastic seeds in *Cassia sericed.*

Mehta and Sen (1990) reported that exposing the seed to 8 hours light and 16 hours to darkness gave 63.3 per cent germination, whereas 10 hours light and 14 hours dark gave in minimum germination of seeds. They also reported that germination was maximum in blue light and minimum in red light whereas there was no germination in complete darkness in ashwagandha seeds.

Gupta *et al.* (1997) reported that seeds treated with concentrated H_2SO_4 for 10 min improved the germination in *Glycyrrhiza glabra.*

Harakumar (1997) reported that seeds of *Gymnema sylvestre* soaked in tap water for 12 hr and followed by soaking in 0.2% KNO_3 solution for 6 hr enhanced the germination up to 75 per cent.

Seal and Gupta (1998) reported that highest rate of germination of 90 per cent in *Sida rhombifolia* and 64 per cent in *Sida acuta* was observed when seeds were treated with 3N H_2SO_4 for 2 and 7 min, respectively.

Kattimani *et al.* (1999 a) Conducted an experiment to study the effect of pre-sowing seed treatments on seed vigour, root length and dry root yield of the medicinal plant of ashwagandha. They reported that soaking the seeds in 1% sodium nitrate gave the highest percentage germination. While seeds soaked with

nitrates of sodium and potassium at 1.0% for 24 hr produced more vigorous seedlings, higher dry matter accumulation and root length as compared to unsoaked and water soaked seeds. Unsoaked seeds had the lowest root length throughout the different stages of crop growth except 15 days after sowing, while zinc nitrate (0.5%) increased root length as compared other treatments. Seeds soaked with nitrates of sodium and potassium at 1.0% recorded maximum dry root yield at harvest.

Bhuyar *et al.* (2000) reported that seeds of *Rauvolfia serpentina*, prior to germination, were subjected to various treatments such as cold water (24 hrs.); hot water (80 degrees C for 5 min) then cooled down to room temperature; sulfuric acid (2 min); sulfuric acid (5 min); sulfuric acid (10 min); gibberellic acid (500 ppm for 24 h); potassium nitrate (0.2% for 24 hrs.). Sulfuric acid produced the highest number of normal seedlings with germination percentage (53.33). (Significant results were also obtained for germination percentage and seedling length in sulfuric acid.)

Verma *et al.* (2001) reported that Sulfuric Acid treatment was effective in breaking *G. glabra* dormancy, while in *P. corilifolia*, scarification of the seed coat with sand paper resulted in 90% germination. The tetrazolium test confirmed the presence of >80% viable embryos in *C.borivillianum*. Unstained and partially stained embryos in *R. serpentine* seeds revealed the presence of non-viable embryos resulting in poor germination. Treatment of *W. somnifera* seeds with 100 ppm gibberellic acid resulted in improved germination.

Ghule *et al.* (2001) conducted the experiment on seed dormancy and standardization of germination in some medicinal plants. They reported that the *Ocimum basilicum* seeds germinated best when seeds were treated with 0.2 per cent of KNO_3 for 24 hours.

Kattimani *et al.* (2001) reported that seed soaking in 1.0% sodium nitrate for 24 hr significantly reduced the number of days taken for germination (9 days), increased the germination percentage (92.13%) and vigour index (670.73), compared with other pre-sowing seed treatments. Whereas soaking of seeds in sodium nitrate (1.0%) resulted in the highest root and shoot lengths at harvest (15.99 and 30.70 cm, respectively). They also reported that the pre-sowing seed treatments significantly increased dry root yield. While soaking of seeds in sodium nitrate recorded the highest dry root yield of 131.03 kg/ha, followed by soaking seeds in potassium nitrate (1.0%) and calcium nitrate (0.5%), which recorded 114.35 and 110.02 kg/ha, respectively in ashwagandha.

Limbale *et al.* (2001) conducted an experiment on stimulation of germination and dormancy studies in some medicinal plants. They revealed that the seed treated 100 ppm Thiourea after hot water soaking (16 hrs) and seed treated with GA_3 400 ppm followed by hot water soaking (32 hrs) resulted better germination in *Cassia fistula* and *Ocimum sanctum* respectively. While seeds of *Withania somnifera* recorded highest germination when soaked in GA_3 400 ppm for 24 hrs.

Suryawanshi *et al.* (2001) studied the requirements for seed germination of medicinal plant species *viz.*, Ashwagandha (*Withania somnifera*), Sabja (*Ocimum pallens*), Dawana (*Artemisia pallens*), Sonamukhi (*Cassia angustifolia*) and wild brinjal (*Solanum viarum*). They reported that the seeds of the above species may be germinated on top of a paper except those of Ashwagandha, which germinated better in between paper. The highest germination (92%) of Ashwagandha seeds was obtained at 20 °C, while the highest germination of Dawana seeds was recorded at 30 °C. The seeds of Sonamukhi, Sabja and wild brinjal showed poor germination due to dormancy. Soaking of seeds in water for 24 hrs and incubation at 20 °C gave the highest germination in Sonamukhi. The seeds treated with 25% nitric acid for 10 minutes and incubation at 30 °C was ideal for Sabja. For wild brinjal, seed treated with 12.5% nitric acid for 15 minutes followed by 1000 ppm gibberellic acid for 24 hr with alternate temperature of 20-30 °C was recommended for better germination.

Vakeswaran (2001) observed that mechanical scarification with sand for 6 min followed by soaking in GA₃ @ 500 ppm for 5 hrs. significantly improved the germination by 21.5 per cent over control in *Withania somnifera*.

Gupta (2002a) conducted experiments revealed that GA₃ was effective in overcome seed dormancy at 5-30 ppm level in *Ocimum* species and KCl, KNO₃ and H₂O₂ were found useful at 1-10 % concentrations they found that significant increase in

seed germination capacity, germination percentage and seedling vigour index in some *ocimum* species.

Gupta (b.2003) conducted an experiment on different medicinal plants to improve germination (dormancy breaking) by using different treatment like scarification, hot water treatment, cold stratification and use of growth regulators (0.2%) KNO_3 treatment is used in two plant species viz., *Costus speciosus* and *Ocimum sanctum* by using top paper method and between paper method in sunlight. They obtained 86% of germination as compared to control (40%).

Velmurugan *et al.* (2003) under taken an experiment on seed germination studies in Ashwagandha (*Withania somnifera*) seeds, by using different chemicals like GA_3 , KH_2PO_4 , Thiourea and water and soil as the media. They reported that GA_3 @ 250 ppm recorded highest percentage of germination (65.3), survival (100 %), shoot length (12.74 cm), shoot: root ratio (1.45), hypocotyls thickness (5.15 cm) and dry matter production (6.42 g/plant). They also reported that there was no significant difference between GA_3 at 250 ppm or KH_2PO_4 at 1 per cent for all above characters.

Choudhury *et al.* (2004) studied on the seed germination of *Rauwolfia serpentina* to determine seed germination in association with vesicular arbuscular mycorrhizas (VAM). The seeds showed 15% germination when associated with VAM. The germination percentage increased (35%), when the seeds were exposed to alternate temperature, sodium hypochlorite (60%)

and sulfuric acid (80%) pre-treatment in association with VAM. The initiation of germination also accelerated with these treatments.

Sriram (2004) reported that the germination capacity of medicinal plants is generally low due to the presence of dormancy. Seed germination response of certain cultivated medicinal plants to various physical and chemical treatments for to break the dormancy and thereby improves the germination percentage.

Alamgir and Ahamed (2005) reported that for propagule development 15 cm cuttings from different regions of 1.5-2 years old plants of *Rauwolfia serpentina* Benth. were used. Root formation and successful propagule development from cuttings of root, stem and root-stem junction were 62, 42 and 78%, respectively 2,4-D at 5 ppm had the highest positive impact on root formation and propagule development (100%), followed by IBA (83% at 50 ppm) and NAA (66% at 10 ppm). IBA and NAA in combination had little positive effect on rooting.

Gupta *et al.* (2005) reported that roots of *Rauwolfia serpentina* are traditionally used for treatment of insomnia, insanity, epilepsy, asthma, high blood pressure and snakebite in Ayurvedic system of medicine. More than 70 compounds are known in *Rauwolfia* among which the reserpine, racenomin are used for control of high blood pressure, whereas ajamalin and ajamalcin are used for cardiac disease under modern system of medicine.

Patil *et al.* (2007) studied the effect of seed source and pre sowing treatment with NaNO_3 , ZnSO_4 , KNO_3 and Thiourea @ 0.5 and 1 per cent, GA_3 at 100 and 200 ppm on germination in Ashwagandha (*Whithania somnifera*). They observed that the treatments GA_3 @ 200 ppm, respectively recorded significantly higher germination (91.67%).

Paul *et al.* (2008) reported that *Rauvolfia serpentina* Benth. can be propagated by both seeds and vegetative propagules, growth of plant and root yield are better in those raised from seeds, but germination of seeds is much lower. Freshly collected seeds of *R. serpentina* were subjected to the various treatments, such as mechanical scarification, hot water soaking, sulphuric acid treatment however, seed scarification with sand paper increased germination percentage to some extent.

2.2 Germination methods:

Chandra (1956) reported that in developing propagules with stem cuttings of 12-15 cm length and 0.4-1.0 cm diameter of *R. conescens* L. by using growth regulators.

Cesevensyees and Baleanu (1987) reported that best medium was top of paper method for germination test in *Atropa belladonna*, *Hypericum pciforatum*, *Solanum lacinatum*, *Solanum sclerea* and *Majorana hortensis*.

Verma *et al.* (1989) reported that top of paper method was best method for conducting germination test in isabgol.

Bhagat *et al.* (1992 a.) reported that seeds of *Ephedra gerandiana* sown in sand medium recorded maximum

germination with shortest period than those sown on soil and filter paper.

Bhagat *et al.* (1992 b.) observed that maximum germination of 97 per cent in *Woodfordia fruticosa* when seeds sown in sand medium compared to brick media and soil, which registered 58 and 43 per cent, respectively.

Dube (1995) observed that the seeds of *Abrus precatorious*, *Cassia angustifolia* gave more germination in between Paper (B.P.) and the seed of *Slilanthus aemella* and *Withania somnifera* was gave more germination recorded in top of paper method.

Kalavathi (1996) reported that sand method was best for conducting the germination test in *Cassia angustifolia* and *Catharanthus roseus* and between paper for *Hibiscus sabdariffa*.

Gagare *et al.* (1998) reported that top of paper method in *Andrographis paniculata* and *Helicteres isova* and between paper was better and quick germination in *Thespesia populanea*.

Suryawanshi *et al.* (2001) reported that top of paper media was found to be the best for conducting germination test in *Solanum viarum*, *Artemisia pallens* and *Cassia angustifolia*.

Vakeswaran (2001) reported that top of paper method was ideal for conducting germination test in *Withania somnifera*.

Gupta (2003) reported that, increasing germination percentage (86%) in top of paper method in *Costus speciosus* and germination percentage (40%) was seen in between paper method in *Ocimum sanctum*.

2.1 Germination temperature

Seeds of different species have required the different ranges of temperature within which they germinate.

Mastalerz (1976) reported that the optimum temperature 20-25 °C was better germination in *Catharanthus roseus*.

Joshua (1978) reported that an alternate temperature of 10-25 °C hastened the germination in *Solanum incanum*.

Roberts *et al.* (1978) reported that seeds germinated rapidly at an alternate temperature of 25/30°C in *Solanum nigrum*.

Wagenvoort and Vanopstal (1979) recommended alternate temperature 25/30°C for improving the germination in *Solanum nigrum* seeds.

Horowitz and Givelberg (1982) reported that *Solanum nigrum* seeds did not germinate in dark but 98 % germination was recorded on 5th day between 20 to 35 °C.

Jatisation (1983) revealed that 28 °C was the most favourable temperature for germination in *Solanum lancinatum*.

Adarshkumar and Bhatnagar (1976) reported that fresh and one year old seed lots of *Dalbergia sissoo*, germinated faster and gave maximum germination at 30 °C in between paper method within nine days. The alternate temperature of 20 and 30 °C, 25 and 30 °C, 30 and 40 °C were also equally effective but high temperatures of 40 °C and 35 to 40 °C were not favourable.

Cesevensyes and Baleanu (1987) reported that the

temperature required for *Atropa belladonna*, *Hypericum perforatum* and *Solanum lacinatedum* was 20 to 30 °C and for *Solanum sclerca* was 30 °C respectively for germination.

Thomson and Wilt (1987) suggested that a constant temperature of 30 °C or alternating temperature regime of 20/30 °C for maximum germination in *Physalis species* and *Solanum ptycanthum*.

Yokoyama and Makai (1988) found that *Trochodendron aralioides* seeds gave 91.7 per cent germination at 28 °C and it ranged from 27 to 37 per cent at low temperatures of 23 °C, 18 °C and 13 °C. Same species gave 81 per cent germination at alternating temperature of 20 and 30 °C and only nine per cent at alternating temperature of 10 and 20 °C

Bahuguna *et al.* (1987) reported that maximum germination (38%) was recorded in *Terminalia myriocarpa* seeds on top of paper with a moisture content of 66.6 per cent at temperature 25 °C.

Thapaliyal (1991) observed that the seeds of *Alnus nitida* and *Alnus nepalensis* gave more germination at 20 and 30 °C whereas in *Alnus nepalensis* the germination was more at 25°C in Between Paper (B.P.) method, while in *Alnus nitida* the best germination was obtained in B.P. and T.P. at 20 °C and 25 °C.

Ganigara *et al.* (1995a) reported that *Dalbergia latifolia* gave maximum germination at constant temperature 25 °C with between paper method. The first count of germination can be taken on fourth day and second count on seventh day.

Ganigara *et al.* (1995b) recommended that the constant temperature of either 25 or 30 °C and sand medium was better for germination test of seeds of *Tamarindus indica*. In *Acacia nilotica* constant temperature of 30 °C and between paper as substratum and first count on third day and final count on seventh day were found to be optimum.

Gawali (1996) observed that under laboratory condition the Between Paper (B.P) substrate at 20°C incubation was found to be suitable with 83.86 per cent mean germination in *Asparagus racemosus* L.

Gagare (1996) reported that seeds of *Andrographis paniculata* treated with KNO₃ (0.5 %) for 24 hours gave 57.20 mean per cent germination at 20 °C by using top of paper (T.P.) substrate.

Miyan (1997) reported that maximum germination per cent was observed in *Acacia aureculiformis* at 35 °C in TP/BP/vermiculite media. In *Acacia catechu* at 25 °C temperatures in TP method gives better germination. Whereas, in *Cassia fistula* gave maximum germination at 25 °C both in TP and BP method. In *Pithecolobium dulce*, the alternate temperature of 20 -30 °C in TP or BP and in *Switenia mahogany* maximum germination percentage was observed at 20, 30 °C and 25 -35 °C in between paper method.

Kalavathi *et al.* (2001) reported that seed testing procedures in some medicinal species, they also observed that the first and final counts could be taken on seventh and

fourteenth day for periwinkle seeds having sand, roll towel and top of paper as media. Whereas sand showed suitable medium with temperature like 20 °C, 25 °C and 30 °C and alternate of 20 -30 °C showed better germination in periwinkle.

Obaremi *et al.* (2002) reported that the seeds were kept at different conditions like light and dark at different temperature (10, 15, 25, 30, 35 and 40 °C) and treatment of leaching at different periods (0, 12, 24, 36 and 48 hours) and using top of paper method at 25 °C temperature method was the ideal for germination.

Pandian *et al.* (2002) reported that pre-soaking of seeds with @ GA₃ 200 ppm for 18 hrs and kept at 30 °C $\pm$ 2 °C for 16 days gave higher germination as compared to water soaking and control seed.

Verma *et al.* (2002) conducted an experiment to standardize the seed testing procedure in medicinal plants of Babechi, Periulinkle and Rosha grass. The seeds placed in three substrata (B.P, T.P and S) at three different temperatures (20, 25 and 30 °C). They also revealed that Babechi seeds showed maximum germination at 25 °C in B.P. and Periulinkle seed showed maximum germination at 30 °C in both B.P. and T.P. substrata.

Lalith Kumar *et al.* (2008) under taken on experiment to standardize seed germination test and storage behaviour in Tulsi, Ashwagandha, Periwinkle and Kalmegh. They reported that in Tulsi, top of paper method with 20/30 °C alternate temperature and light (24hr) recorded the highest germination

(84.80%). While between paper method at 25 °C constant temperature with 24 hr light was found suitable for germination test and recorded maximum germination (84.90%) at 10 days in ashwagandha. Whereas in Periwinkle seeds recorded highest germination (90.70%) in between paper method at 20 °C in dark with KNO₃ while top of paper at 15 °C with 24 hr light was found suitable for maximum germination (78.80%) in Kalmegh.

Sahai and Rawat (2009) revealed that the seed sterility was comparatively high in wild and cultivated *Rauvolfia serpentina*. Prolonged application of asexual mode of propagation in cultivated taxa leading to weak genetic diversity might be responsible for high seed sterility.

Gagare and Mate (2009) reported that effects of substrate in sand, between paper, top paper and temperature (20 or 30° C) on the germination of *C. crista* and *F. limonia* seeds were studied. The germination of *C. crista* was highest in sand at 30 degrees C and lowest when seeds were germinated between sheets of paper at 30 degrees C. *F. limonia* germination was most pronounced when the seeds were germinated between sheets of paper at 30 degrees C and lowest when the seeds were germinated on paper and in sand at 20 degrees C.

Pandey and Mandal (2010) carried out an experiment to find out the influence of propagation techniques and harvesting time on root yield and total alkaloid content of the *Rauvolfia serpentina* under tropical climatic conditions. Results revealed that harvesting time had pronounced effect on quality and yield

of the herb. However, propagation techniques did not have significant effect on total alkaloid content. Highest root yield and alkaloid content was obtained in the crop raised through seeds harvested after 18 months of planting.

Mishra *et al.* (2010) reported that the seeds collected from Non-wood Forest Produce division of the institute were used for optimization of seed germination employing various concentrations of GA₃ and mechanical scarification treatment. Among various treatments scarified seed treated with GA₃ 300 ppm were found to be most effective and showed maximum of 62.67% germination.

Dey and De (2010) reported that the *Rauvolfia serpentina* commonly known as Sarpagandha is an important medicinal plant of Indian subcontinent and South East Asian countries. The plant grows generally in the region with annual rainfall of 200-250 cm and up to an altitude of 1000 m and favours deep fertile soil rich in organic matter. Poor seed germination rate, over exploitation and loss of habitat are the major causes of decline of this species from its natural habitat.

Axay Kumar *et al.* (2010) carried out an experiment to find out the suitable substrata and temperature requirements for germination testing in *Jatropha* seed, collected from six different locations of Haryana. The seed lots were tested on sufficient moistened three substrata *viz.*, sand, B. P. and T. P. and at four different temperatures 20, 25, 20-30 and 30 degrees C with 90-95% RH in seed germinator. Highest germination was observed in sand followed by between paper.

Shukla *et al.* (2010) carried out an experiment consisting six growing media (*viz.*, soil, 1 soil:1 sand:2FYM , 1 soil:1 sand:1 FYM , 1 soil:1 FYM , 1 soil:1 sand and 2 soil:1 sand) and three seed weight (25, 25-50 and above 50 g) were analyzed to study the effect on germination and seedling growth of *Melocanna baccifera* (Roxb.) Seeds of above 50 g weight sown in equal proportion of soil, sand and FYM gave significantly better germination and seedling growth than other media used.

Sachan *et al.* (2010) reported that the germination test of kalaunji seed should be conducted on Top of the Paper media at 20 degrees C temperature. The optimum days for first and final count for germination were 6 and 10 days, respectively.

Trivedi and Kumari (2011) studies were conducted to determine the germination behavior and ethno botanical aspects of *Rauvolfia serpentina*. The germination tests, unscarified seeds did not germinate at all, while freshly harvested scarified seeds showed 54% germination. In response to growth regulators, the scarified seeds showed 95.2% germination at 25 and 100 ppm cytokinin, 90.4% at 100 ppm IAA and 77.4% at 100 ppm gibberellic acid.

Panwar and Guru (2012) studied on the seed germination behavior of *R. serpentina* under controlled environmental conditions. Seed germination was as low as 20.47% in case of intact seeds and was improved up to 40.2% after removal of the seed coat. The improved seed germination may be ascribed as the synergistic effect of the removal of seed coat as well as the optimal concentration of GA₃.

Bariar and Prasad (2012) reported that *R. serpentine* Benth. and *R. tetraphylla* L. the effects of acute gamma irradiation (60Cobalt-source) on the seed germination and survival is highlighted and discussed. The radio-sensitivity and radio-resistance in the two species, besides the nature and elimination of dormancy in these species is discussed.

Krishna *et al.* (2011) reported that the significantly higher germination and speed of germination was noticed in larger seeds (2.2 mm) followed by medium seeds (2.0 mm) in *Withania somnifera* Dunal. They also observed that reduced the rate of speed of germination, seedling dry weight, root length, shoot length and vigour index, respectively with decrease in the size of seed (1.8 mm) and they also reported that the maximum seed germination as was obtained in seeds soaked with KNO₃ 1% solution for 6 hrs and dried back to original weight followed by GA₃ 100 ppm treatment compared to untreated seeds.

Gehlot and Kasera (2011) observed the seed morphology, germination (%), and vigour index (VI) in fresh and one-year-old seed (stored under controlled laboratory conditions) in *Withania coagulans*. T Fresh seed showed 90% germination in 0.10% CaNO₃, whereas, one-old-seed responded favorably for germination with NH₄NO₃ (0.75%) and CaNO₃ (0.50%) solutions. The highest R/S ratio was observed with KNO₃ (0.25%) and NH₄NO₃ (0.50%) solutions, respectively.

Pawar *et al.* (2011) studied the influence of growth regulators on seed germination of some Dashamool *species*. They

reported that fresh seeds of three Dashamool *spp. viz.*, Dorali (*Solanum indicum*), Bhuirigni (*Solanum xanthocarpum*) and Bael (*Aegle marmelose*) soaked in different plant growth regulators at different concentrations *viz.*, KNO₃, GA₃, NH₄NO₃, IAA and IBA for 23 hrs. They reported that significant differences were observed due to plant growth regulators for germination percentage, days required to 50% flowering, root-shoot length and vigour index. They also reported that the GA₃ 500 ppm and 750 ppm for 24 hrs soaking gave higher germination in the seeds of *Solanum indicum* and *Solanum xanthocarpum* as compared to other treatments. While in *Aegle marmelos* 0.5% NH₄NO₃ and 2% NH₄NO₃ give significant higher germination percentage as compared to other treatments.

Rajasaheb *et al.* (2011) reported that ashwagandha seed were soaked in chemical solution *viz.*, Conc. H₂SO₄ for five minutes, in KNO₃ (1%) 6th hrs, GA₃ 100 ppm, cow urine for overnight and water soaking for 12 hrs. They exhibited significant differences in seed germination percentage. The seeds soaked in KNO₃ 1% solution for 6 hrs had recorded significantly higher seed germination percentage (79.00%), speed of germination, seedling dry weight (13.46 mg) and vigour over control, except the seeds treated with Conc. H₂SO₄ for 1 min. They also reported that seeds treated with KNO₃ recorded maximum root length and shoot length followed by seeds treated with GA₃ 100 ppm with light treatment. There was increase in germination and it's parameters might be attributed by KNO₃ 1% and 100 ppm of GA₃ are involved in maintaining vigour and

efficiency of the seed germination. The KNO_3 and GA_3 may be playing a critical role in increasing the physiological efficiency during the seed germination.

Susila and Jyothsna (2013) standardized an *in vitro* culture technique for mass propagation of an endangered medicinal plant *Rauvolfia serpentina*. The best shoot proliferation was observed in M S medium containing 0.1 mg L^{-1} NAA and 2.5 mgL^{-1} BA, where 92% of plants showed proliferation. For rooting, half strength M S medium supplemented with 0.4 mgL^{-1} NAA and 0.1 mgL^{-1} IBA showed maximum root formation (91%). After acclimatization and transplantation, 90% of the *in vitro* derived plants survived in *ex vivo* condition.

Khan (2013) reported that *Bixa arellana* L is economically important species but have poor germination and seed dormancy. In this connection the attempt made to study the germination potential of the *B. arellana*. The different treatment has been tried such on small incision or clipping at the top end of the seed coat, mechanical scarification by sand paper technique, hot and cold water treatment for different time period. The study investigated the effect of different treatments such as H_2SO_4 , KNO_3 , Thiourea at different concentration. Among all the treatments GA_3 at different concentration Thiourea and KNO_3 treatments were found more effective.

Venudevan *et al.* (2013) studies were conducted on standardization of media and methodologies for germination test under germination room conditions in line with ISTA for Bael

seeds. The results revealed that, either river sand or paper media could be used for obtaining reproducible and complete expression of germination of seed. In river sand, in-sand method and in paper, between paper method had better expression for germination.

Soliman and Abbas (2013) reported that acid scarification for 2 minutes and then soaking in hot water at 100°C for 6 minutes was the best method for breaking dormancy of *Cassia fistula* which resulted in an increased germination percentage.

Pallavi *et al.* (2014) reported that different dormancy breaking treatments were imposed on freshly harvested seeds of *Abrus precatorius* to improve germination. Treatment includes physical and physiological methods like soaking in water, conc. H₂SO₄, KNO₃ (2%), GA₃ 100 ppm, Kinetin 100 ppm and mechanically damaging the seed coat. The experimental results revealed that among all treatments damaging the seed coat enhanced germination from 32 to 84%, followed by seeds soaked in gibberlic acid 100 ppm.

Verma *et al.* (2014) reported that Khurasani- ajvayan *Hyoscyamus niger L.* is an important medicinal plant which is having high percentage of hard seeds. The germination test was conducted in the laboratory at three different temperatures (20, 25 and 30°C) and substrata (BP, TP and S). The seeds of shows better germination in BP/TP substrata at 30°C after soaking the seeds in GA₃ solution for 24hours the final count for germination should be taken after 12 days.

3. MATERIAL AND METHODS

The present investigation entitled, “Standardization of seed germination testing procedure in sarp Gandha (*Rauvolfia serpentina*),” was conducted during 2014-15 at Seed Technology Research Unit (STRU) Laboratory and Medicinal and Aromatic Plant Project (Dhanwantri garden), M.P.K.V., Rahuri, (Maharashtra state). The details of the material used and methods adopted for the investigation are described under various sub headings in this chapter.

3.1 Experimental Material

The fresh seeds of sarp Gandha (*Rauvolfia serpentina*) were collected from Medicinal and Aromatic Plant Project, M.P.K.V., Rahuri during 2014-2015 from their natural stand.

3.2 Treatment details

To standardize the suitable germination testing method, treated seeds were kept for germination by different method at different temperature and recorded the normal seedling percentage.

3.2.1 Treatments

To assess the effect of different treatments on seed germination the seed are treated as detailed given below.

T₁ - Control (Untreated seeds)

The untreated seeds were considered as control.

T₂ – H₂SO₄ conc. Treatment for 3 minutes

The conc. sulphuric acid solution was taken and the seed were treated with conc. H₂SO₄ solution for 3 min. followed by washing the seed with tap water. After the treatment and washing the seeds were dried under shade.

T₃ - H₂SO₄ conc. Treatment for 5 minutes

The conc. sulphuric acid solution was taken and the seed were treated with conc. H₂SO₄ solution for 5 min. followed by washing the seed with tap water. After the treatment and washing the seeds were dried under shade.

T₄- H₂SO₄ conc. Treatment for 10 minutes

The conc. sulphuric acid solution was taken and the seed were treated with conc. H₂SO₄ solution for 10 min. followed by washing the seed with tap water. After the treatment and washing the seeds were dried under shade.

T₅- Soaking in KH₂ PO₄ (1%) for 24 hrs.

1 g KH₂ PO₄ was dissolved in 100 ml of distilled water for preparation 1% potassium dihydrogen phosphate solution and the seeds were soaked for 24 hrs. followed by shade drying.

T₆- Soaking in KNO₃ (1%) for 24 hrs.

1 g KNO₃ was dissolved in 100 ml of distilled water for preparation 1% potassium nitrate solution and the seeds were soaked for 24 hrs. followed by shade drying.

T₇- Soaking in KNO₃ (2%) for 24 hrs.

2 g KNO₃ was dissolved in 100 ml of distilled water for preparation 2% potassium nitrate solution and the seeds were soaked for 24 hrs. followed by shade drying.

T₈- Soaking in Thiourea (0.5%) for 5 min

0.5 g Thiourea was dissolved in 100 ml of distilled water for preparation 0.5 % Thiourea solution and the seeds were soaked for 5 min followed by shade drying.

T₉- Soaking in cow urine for 6 hrs

The seeds were soaked in cow urine for 5 min followed by shade drying.

T₁₀ - Mechanical scarification

Seeds were scraped with sand paper so as to facilitate water imbibition.

T₁₁ - Stratification

The seeds were placed on plastic trays and were kept in the deep freezer for 24 hrs.

T₁₂ - Water soaking

Seeds were soaked in tap water for 24 hrs. then dried in shade.

3.2.2 Germination Methods

M₁ Between paper method (BP)

M₂ Sand method (SM)

M₃ Top of paper method (TP)

M₄ Cocopeat Method (CM)

3.2.3 Temperatures

C₁ 20 $\pm$ 2 °C

C₂ 25 $\pm$ 2 °C

C₃ 30 $\pm$ 2 °C

3.2.4 Treatments combination

Combination	Combination details
M ₁ C ₁	Between paper x 20 $\pm$ 2 ⁰ C
M ₁ C ₂	Between paper x 25 $\pm$ 2 ⁰ C
M ₁ C ₃	Between paper x 30 $\pm$ 2 ⁰ C
M ₂ C ₁	Sand method x 20 $\pm$ 2 ⁰ C
M ₂ C ₂	Sand method x 25 $\pm$ 2 ⁰ C
M ₂ C ₃	Sand method x 30 $\pm$ 2 ⁰ C
M ₃ C ₁	Top of paper x 20 $\pm$ 2 ⁰ C
M ₃ C ₂	Top of paper x 25 $\pm$ 2 ⁰ C
M ₃ C ₃	Top of paper x 30 $\pm$ 2 ⁰ C
M ₄ C ₁	Cocopeat method x 20 $\pm$ 2 ⁰ C
M ₄ C ₂	Cocopeat method x 25 $\pm$ 2 ⁰ C
M ₄ C ₃	Cocopeat method x 30 $\pm$ 2 ⁰ C

The germination test was conducted with 100 seeds of sarpgandha (*Rauvolfia serpentina*) which were counted randomly from treated and well mixed lot. Seeds were kept for germination in four replications, as per the treatment combinations given above. The final count, was taken when the maximum number of seedlings were observed. The number of normal seedlings were observed in different methods and expressed as percentage.

3.3 Observations recorded

1. Germination percentage (%)

Hundred seeds was randomly taken from each treatment in four replications and germinated in different media as mentioned in 3.2.2 in germinator at, three temperatures i.e. $20 \pm 2^{\circ}\text{C}$, $25 \pm 2^{\circ}\text{C}$ and $30 \pm 2^{\circ}\text{C}$. The 90% humidity was maintained in the germinator. The number of normal seedlings was counted up to 21days and expressed in percentage.

2. Root length (cm)

Ten normal seedlings were selected randomly from germination test of and all the replications on eighth day. The root length was measured from the top of the primary root to base of hypocotyls and mean root length was expressed in centimeters.

3. Shoot length (cm)

Ten normal seedlings used for root length measurement were also used for the measurement of shoot length. The shoot length was measured from the base of the primary leaf to the base of the hypocotyls and mean shoot length was expressed in centimeters.

4. Vigour index I

Ten normal seedlings were selected randomly immediately after germination test. Total root shoot length (cm) of ten seedlings was measured and average was worked out for calculating the seedling vigour index I.

The vigour index was computed by formula suggested by Abdul-Baki and Anderson (1973) as below.

$$\text{Vigour Index-I} = \left[\frac{\text{Mean root length (cm)} + \text{Mean shoot length (cm)}}{2} \right] \times \frac{\text{Germination percentage}}{100}$$

5. Dry matter content of seedling (mg)

Ten normal seedlings selected for shoot and root length measurement was kept in an oven maintained at 50°C for 24 hours. After drying, the weight of dry seedlings was recorded and mean weight was calculated and expressed in milligrams (mg).

6. Vigour index II

The seedling selected for calculating seedling vigour index I was oven dried and the oven dried weight of seedlings was used for calculating seedling vigour index II.

Seedling vigour index II was determined by using the formula given by Abdul-Baki and Anderson (1973) as below.

$$\text{Vigour Index-II} = \text{Average dry seedling wt. (g)} \times \text{Germination \%}$$

7. Electrical Conductivity (dSm⁻¹)

Four replications each of 50 seeds were randomly counted from each treatment and were soaked in 75 ml distilled water for 24 hr. The electrical conductivity of solution was measured by using conductivity meter and expressed in desicimen per meter.

8. Seed mycoflora (%)

The seed health was determined by blotter test to detect the presence of seed-borne fungi of sarpagandha seeds. Three layers of blotters (size fitting to the size of petridish) soaked in sterilized distilled water were placed in petridish. Ten seeds were placed in each petridish and the petridishes were kept in incubator at 20 ± 2°C for 7 days beneath near ultraviolet light with a cycle of 12 hrs. light and 12 hrs. darkness. Four replications were maintained. The

seeds were examined on 8th day under stereoscopic binocular microscope. The fungi were identified on the basis of sporulation and their fruiting structures.

9. Moisture content (%)

Moisture content was determined by Hot Air Oven method by drying 10 gm of sarpgandha seeds at 103 °C for 17 hours in hot air oven. The percentage of moisture content was calculated on the weight basis.

$$\text{Moisture content} = \frac{M_2 - M_3}{M_2 - M_1} \times 100$$

Where,

M1 = Weight of container with lid.

M2 = Weight of container with lid + seed before drying.

M3 = Weight of container with lid + seed after drying.

10. 100 seed weight (g)

Hundred seeds in each treatment were counted manually and used for recording the seed weight. The average hundred seed weight was recorded in grams (g).

3.4 Storage studies

After standardization of seed germination procedure, the seed were kept for storage in high density polyethylene bag (HDEP) at room temperature to assess the seed storability and quality of sarpgandha seed during storage.

3.5 Statistical Analysis

The statistical data was analyzed by the FCRD method as per the procedure given by Snedecor and Cochran (1994).

4. EXPERIMENTAL RESULTS

4.1 Standardization of seed germination.

The present investigation entitled, “Standardization of seed germination testing procedure of sarpgandha (*Rauvolfia serpentina*)” was under taken to standardize the suitable method for germination and to assess the effect of seed treatments on growth and seed quality of sarpgandha. The results of present investigation have been presented in this chapter.

4.1.1 Effect of seed treatment on germination, root and shoot length.

The data regarding effect of seed treatment on germination, root and shoot length of sarpgandha are presented in Table 1.

4.1.1.1 Effect of seed treatment on germination (%)

It was evident from the data that the germination was significantly differed due to different seed treatment. Among the treatments, 2% KNO₃ (T₇) showed higher germination (38.75 %) than other treatments however, the cold stratification (T₁₁) recorded the lowest germination (15.58 %).

4.1.1.2 Effect of seed treatment on root length (cm)

From the Table 1, it was evident that the root length was significantly differed due to different seed treatments. Among the treatments, 2% KNO₃ (T₇) showed higher root length (2.88 cm) than other treatments however, cold stratification (T₁₁) recorded the lowest root length (1.59 cm).

4.1.1.3 Effect of seed treatment on shoot length (cm)

From the Table 1, it was evident that the shoot length was significantly differed due to different seed treatments.

Among the treatments, 2% KNO₃ (T₇) showed higher shoot length (6.94 cm) than other treatments however, cold stratification (T₁₁) recorded the lowest shoot length (5.08 cm).

Table 1 Effect of seed treatment on germination, root and shoot length.

Treatment	Germination (%)	Root length (cm)	Shoot length (cm)
T1: Control	18.08 (24.70)*	1.90	5.50
T2: conc.H ₂ SO ₄ (3min)	28.58 (31.96)	2.45	6.33
T3: conc.H ₂ SO ₄ (5min)	20.67 (26.52)	2.31	5.98
T4: conc.H ₂ SO ₄ (10min)	12.96 (19.79)	1.75	5.45
T5: 1% KH ₂ PO ₄	25.67 (30.12)	2.35	6.15
T6: 1% KNO ₃	31.92 (34.19)	2.64	6.53
T7: 2% KNO ₃	38.75 (38.41)	2.88	6.94
T8: 0.5% Thiourea	25.21 (29.95)	2.31	6.05
T9: Cow urine	21 (26.72)	1.79	5.18
T10: Mechanical scarification	23.46 (28.07)	2.05	5.63
T11: Stratification	15.58 (21.81)	1.59	5.08
T12: Water soaking	20.67 (25.13)	1.90	5.66
SE ±	0.507	0.050	0.087
CD @ 5%	1.416	0.139	0.242

*Figures in parentheses indicate arcsine transformed values.

4.1.2 Effect of germination methods on germination, root and shoot length.

The results on effect of germination methods, on germination, root and shoot length and their interactions are presented below.

4.1.2.1 Effect of germination methods on germination (%)

The data regarding effect of germination methods on germination is presented in the Table 2.

The data revealed that the differences for germination were significant due to different germination methods. The highest germination was recorded in the sand method (M₂) (33.54 %) whereas, the lowest germination was noticed in cocopeat method (M₄) (18.82 %).

Table 2 Effects of germination methods on germination, root and shoot length.

Germination methods	Germination (%)	Root length (cm)	Shoot length (cm)
M ₁ : Between paper	20.5 (26.50)*	1.78	6.07
M ₂ : Sand method	33.54 (35.12)	3.66	7.77
M ₃ : Top of paper	21.32 (27.13)	1.73	5.14
M ₄ : Cocopeat	18.82 (23.72)	1.49	4.52
SE $\pm$	0.293	0.029	0.050
CD @ 5%	0.818	0.080	0.140

*Figures in parentheses indicate arcsine transformed values.

4.1.2.2 Effect of germination methods on root length (cm)

The data on effect of different germination methods on root length are presented in the Table 2, from the data it was evident that the root length was significantly differed due to different germination method. The highest root length (3.66 cm) was recorded in sand method (M₂). The lowest root length (1.49 cm) was recorded in cocopeat method (M₄).

4.1.2.3 Effect of germination methods on shoot length (cm)

The data regarding effect of different germination methods on shoot length are presented in the Table 2, it was evident from the table that, there were significant effects of germination methods on shoot length. The highest shoot length (7.77 cm) was recorded in sand method (M₂). The lowest shoot length (4.52 cm) was recorded by cocopeat method (M₄).

4.1.3 Effect of temperature on germination, root and shoot length.

The data regarding effect of temperature on germination, root and shoot length are presented in the Table 3.

4.1.3.1 Effect of temperature on germination (%)

The data on effect of temperature on germination are presented in the Table 3.

It was evident that temperature had significant effect on germination. The highest germination was recorded at the $30 \pm 2^{\circ}\text{C}$ temperature (29.51 %) (C₃). The lowest germination (17.53 %) was recorded at $20 \pm 2^{\circ}\text{C}$ temperature (C₁).

Table 3 Effect of temperature on germination, root and shoot length

Temperature	Germination (%)	Root length (cm)	Shoot length (cm)
C ₁ : $20 \pm 2^{\circ}\text{C}$	17.53 (23.28)*	1.81	5.45
C ₂ : $25 \pm 2^{\circ}\text{C}$	23.59 (28.47)	2.23	5.97
C ₃ : $30 \pm 2^{\circ}\text{C}$	29.51 (32.60)	2.45	6.20
SE $\pm$	0.253	0.025	0.043
CD @ 5%	0.708	0.070	0.121

*Figures in parentheses indicate arcsine transformed values

4.1.3.2 Effect of temperature on root length (cm)

From the data it was revealed that temperature had significant effect on root length. The maximum root length was recorded at the $30 \pm 2^{\circ}\text{C}$ temperature (2.45 cm) (C_3). The minimum root length (1.81 cm) was recorded at $20 \pm 2^{\circ}\text{C}$ temperature (C_1).

4.1.3.3 Effect of temperature on shoot length (cm)

The data on effect of temperature on shoot length are presented in the Table 3.

From the data it was observed that temperature had significant effect on shoot length. The maximum shoot length was recorded at the $30 \pm 2^{\circ}\text{C}$ temperature (6.20 cm) (C_3). The minimum shoot length (5.45 cm) was recorded at $20 \pm 2^{\circ}\text{C}$ temperature (C_1).

4.1.4 Interaction effect of germination methods and seed treatment on germination, root and shoot length.

The data regarding effect of interaction between germination method and seed treatment on germination, root and shoot length are presented in the Table 4.

4.1.4.1 Interaction effect of germination methods and seed treatments on germination (%)

The data on interaction effect of germination methods and seed treatment on germination are presented in the Table 4. It was observed that the interactions of germination method and seed treatment had significant effect on germination. The interaction of germination in sand and seed treated with 2% KNO_3 (M_2T_7) showed significantly higher germination (50.83 %). The lowest germination (7.5 %) was observed in the

interaction of germination in cocopeat and seed kept for cold stratification (M₄T₁₁).

Table 4 Interaction effect of germination methods and seed treatment on germination, root and shoot length.

Treatment combination	Germination (%)	Root length (cm)	Shoot length (cm)
M1T1	14 (21.91)*	1.68	5.64
M1T2	29.33 (32.71)	1.97	6.51
M1T3	22.67 (28.34)	1.79	6.08
M1T4	12.67 (20.78)	1.72	5.39
M1T5	26 (30.60)	1.92	6.35
M1T6	29.33 (32.73)	2.03	6.89
M1T7	33.33 (35.24)	2.07	7.61
M1T8	21.67 (27.63)	1.83	6.26
M1T9	14 (21.93)	1.50	5.41
M1T10	18 (24.90)	1.63	5.69
M1T11	10.67 (19.02)	1.43	5.32
M1T12	14.33 (22.19)	1.75	5.73
M2T1	28.33 (32.08)	2.84	7.41
M2T2	39.17 (38.64)	4.32	8.24
M2T3	27.5 (31.34)	4.08	7.85
M2T4	20 (26.26)	2.76	7.58
M2T5	35.83 (36.64)	3.98	7.94
M2T6	42.5 (40.62)	4.74	8.25
M2T7	50.83 (45.48)	5.24	8.41
M2T8	34.17 (35.70)	3.92	7.94
M2T9	32.5 (34.42)	2.66	7.29
M2T10	32.5 (34.61)	3.45	7.59
M2T11	25.83 (30.46)	2.59	7.08

Table 4 continued.....

Treatment combination	Germination (%)	Root length (cm)	Shoot length (cm)
M2T12	33.33 (35.21)	3.28	7.70
M3T1	15 (22.60)	1.66	4.49
M3T2	24.17 (29.18)	1.84	5.66
M3T3	18.33 (25.25)	1.73	5.46
M3T4	11.67 (19.60)	1.47	4.37
M3T5	20 (26.45)	1.92	5.62
M3T6	27.5 (31.54)	2.04	5.99
M3T7	35.83 (36.75)	2.24	6.47
M3T8	22.5 (28.19)	1.66	5.40
M3T9	17.5 (24.52)	1.53	4.42
M3T10	25 (29.81)	1.67	4.80
M3T11	18.33 (25.25)	1.38	4.36
M3T12	20 (26.45)	1.66	4.68
M4T1	15 (22.25)	1.44	4.50
M4T2	21.67 (27.31)	1.67	4.92
M4T3	14.17 (21.18)	1.66	4.55
M4T4	7.5 (12.53)	1.07	4.47
M4T5	20.83 (26.80)	1.59	4.70
M4T6	28.33 (31.90)	1.78	5.03
M4T7	35 (36.20)	1.99	5.28
M4T8	22.5 (28.28)	1.85	4.63
M4T9	20 (26.05)	1.51	3.64
M4T10	18.33 (23.00)	1.47	4.45
M4T11	7.5 (12.53)	0.94	3.56
M4T12	15 (16.68)	0.98	4.56
SE $\pm$	1.01	0.100	0.173
CD @ 5%	2.832	0.279	0.485

*Figures in parentheses indicate arcsine transformed values

4.1.4.2 Interaction effect of germination methods and seed treatments on root length (cm)

From the data it was noticed that the interaction of germination method and seed treatment had significant effect on root length. The interaction of germination in sand and seed treated with 2% KNO₃ (M₂T₇) showed significantly higher root length (5.24 cm) followed by the interaction of germination in sand and seed treated with 1% KNO₃ (M₂T₆) (4.74 cm). The lowest root length (0.98 cm) was observed in the interaction of germination in cocopeat and seed kept for stratification (M₄T₁₁). (Table 4)

4.1.4.3 Interaction effect of germination methods and seed treatments on shoot length (cm)

The data on interaction effect of germination method and seed treatment on shoot length are presented in the Table 4.

It was observed that the interactions of germination methods and seed treatments had significant effect on shoot length. The interaction of germination in sand and seed treated with 2% KNO₃ (M₂T₇) showed significantly higher shoot length (8.41 cm) followed by the interaction of germination in sand and seed treated with 1% KNO₃ (M₂T₆) (8.25 cm). The lowest shoot length (3.56 cm) was observed in the interaction of germination in cocopeat and seeds kept for stratification (M₄T₁₁).

4.1.5 Interaction effect of temperature and seed treatments on germination, root and shoot length.

The data regarding effect of interaction temperature and seed treatments on germination, root and shoot lengths are presented in the Table 5.

4.1.5.1 Interaction effect of temperature and seed treatments on germination (%)

The data on interaction effect of temperature and seed treatments on germination are presented in the Table 5. It was observed that the interactions of temperature and seed treatments had significant effect on germination. The interaction of temperature $30 \pm 2^{\circ}\text{C}$ and seed treated with 2% KNO_3 (C_3T_7) showed significantly higher germination (43.63 %) followed by the interaction of temperature $25 \pm 2^{\circ}\text{C}$ (C_2T_7) and seed treated with 1% KNO_3 (39.54 %). The lowest germination (7.5 %) was observed in the interaction of temperature $20 \pm 2^{\circ}\text{C}$ and seeds kept for stratification (C_1T_{11}).

4.1.5.2 Interaction effect of temperature and seed treatments on root length (cm)

The data on interaction effect of temperature and seed treatments on root length are presented in the Table 5. It was observed that the interactions of temperature and seed treatments had significant effect on root length. The interaction of temperature $30 \pm 2^{\circ}\text{C}$ and seed treated with 2% KNO_3 (C_3T_7) showed significantly higher root length (3.05 cm) followed by interaction of temperature $25 \pm 2^{\circ}\text{C}$ and seed treated with 2% KNO_3 (C_2T_7) (2.89 cm). The lowest root length (1.19 cm) was observed in the interaction of temperature $20 \pm 2^{\circ}\text{C}$ and seed kept for stratification (C_1T_{11}).

Table.5 Interaction effects of temperature and seed treatments on germination, root and shoot length.

Treatment combination	Germination (%)	Root length (cm)	Shoot length (cm)
C1T1	13 (20.67)*	1.70	5.28
C1T2	20.38 (26.46)	2.04	5.71
C1T3	14.13 (21.54)	1.83	5.50
C1T4	11 (16.70)	1.32	5.26
C1T5	18.88 (25.51)	2.00	5.59
C1T6	24.38 (29.41)	2.41	6.01
C1T7	33.13 (35.06)	2.72	6.48
C1T8	21.13 (27.16)	1.87	5.62
C1T9	14.5 (22.04)	1.54	4.68
C1T10	16.63 (22.29)	1.74	5.34
C1T11	7.5 (13.68)	1.19	4.59
C1T12	15.75 (18.88)	1.39	5.40
C2T1	18.25 (24.98)	2.00	5.58
C2T2	28.5 (32.09)	2.61	6.57
C2T3	19.88 (26.21)	2.45	6.04
C2T4	12 (19.76)	1.89	5.45
C2T5	26 (30.42)	2.36	6.23
C2T6	33.5 (35.26)	2.67	6.63
C2T7	39.5 (38.88)	2.89	7.05
C2T8	26.75 (31.00)	2.38	6.06

Table 5 continued.....

Treatment combination	Germination (%)	Root length (cm)	Shoot length (cm)
C2T9	20.13 (26.37)	1.86	5.43
C2T10	23 (28.39)	1.96	5.70
C2T11	15.88 (22.54)	1.74	5.33
C2T12	19.75 (25.80)	1.96	5.68
C3T1	23 (28.48)	2.01	5.67
C3T2	36.88 (37.33)	2.70	6.71
C3T3	28 (31.83)	2.66	6.42
C3T4	19.38 (25.93)	2.06	5.64
C3T5	32.13 (34.43)	2.71	6.65
C3T6	37.88 (37.92)	2.86	6.98
C3T7	43.63 (41.31)	3.05	7.30
C3T8	27.75 (31.69)	2.70	6.49
C3T9	28.38 (31.77)	1.99	5.45
C3T10	30.75 (33.55)	2.47	5.86
C3T11	19.88 (26.21)	1.85	5.33
C3T12	26.5 (30.72)	2.37	5.92
SE $\pm$	1.211	0.086	0.150
CD @ 5%	3.386	0.241	0.451

*Figures in parentheses indicate arcsine transformed values

4.1.5.3 Interaction effect of temperature and seed treatments on shoot length (cm)

The data on interaction effect of temperature and seed treatments on shoot length are presented in the table 5. It was observed that the interaction of temperature and seed

treatments showed significant effect on shoot length. The interaction of temperature $30 \pm 2^{\circ}\text{C}$ and seed treated with 2% KNO_3 (C_3T_7) showed significantly higher shoot length (7.30 cm) followed by the interaction of temperature $25 \pm 2^{\circ}\text{C}$ and seed treated with 2% KNO_3 (C_2T_7) (7.05 cm). The lowest shoot length (4.59 cm) was observed in the interaction of temperature $20 \pm 2^{\circ}\text{C}$ and seeds kept for stratification (C_1T_{11}).

4.1.6 Interaction effect of germination methods and temperature on germination, root and shoot length.

The data regarding effect of interaction between germination methods and temperature on germination, root and shoot length are presented in the Table 6.

4.1.6.1 Interaction effect of germination methods and temperature on germination (%)

The data on interaction effect of germination methods and temperature on germination are presented in the Table 6. It was observed that the interactions of germination methods and temperature had significant effect on germination. The interaction of germination in sand and kept at $30 \pm 2^{\circ}\text{C}$ for germination (M_2C_3) showed significantly higher germination (40.03 %) than the rest of interactions followed by germination in sand and kept at $25 \pm 2^{\circ}\text{C}$ for germination (M_2C_2) (35.08 %). The lowest germination (10.42 %) was observed in the interaction of germination in cocopeat kept at $20 \pm 2^{\circ}\text{C}$ for germination (M_4C_1).

Table 6 Interaction effect of germination methods and temperature on germination, root and shoot length.

Treatment combination	Germination (%)	Root length (cm)	Shoot length (cm)
M1C1	17.42 (24.28)*	1.65	5.66
M1C2	20 (26.19)	1.78	6.09
M1C3	24.08 (29.02)	1.90	6.47
M2C1	25.63 (30.11)	3.00	7.56
M2C2	35 (36.13)	3.74	7.76
M2C3	40 (39.13)	4.22	8.00
M3C1	16.67 (23.72)	1.53	4.52
M3C2	20.83 (26.88)	1.77	5.39
M3C3	26.46 (30.80)	1.89	5.52
M4C1	10.42 (15.03)	1.06	4.08
M4C2	18.54 (24.70)	1.62	4.68
M4C3	27.5 (31.44)	1.80	4.81
SE $\pm$	0.507	0.050	0.087
CD @ 5%	1.416	0.139	0.242

*Figures in parentheses indicate arcsine transformed values

4.1.6.2 Interaction effect of germination methods and temperature on root length (cm)

The data on interaction effect of germination methods and temperatures on root length are presented in the Table 6. It was observed that the interactions of germination methods

and temperature had significant effect on root length. The interaction of germination in sand kept at $30 \pm 2^{\circ}\text{C}$ for germination (M_2C_3) showed significantly higher root length (4.22 cm) than the rest of interactions followed by interaction of germination in between paper kept at $30 \pm 2^{\circ}\text{C}$ (M_1C_3) (3.74cm). The lowest root length (1.06 cm) was observed in the interaction of germination in cocopeat kept at $20 \pm 2^{\circ}\text{C}$ (M_4C_1).

4.1.6.3 Interaction effect of germination methods and temperature on shoot length (cm)

From the data it was observed that the interactions of germination methods and temperature had significant effect on shoot length. The interaction of germination in sand kept at $30 \pm 2^{\circ}\text{C}$ (M_2C_3) showed significantly highest shoot length (8.00 cm) followed by interaction of germination in sand kept at $25 \pm 2^{\circ}\text{C}$ (M_2C_2) (7.76 cm). The lowest shoot length (4.08 cm) was observed in the interaction of germination in cocopeat kept at $20 \pm 2^{\circ}\text{C}$ (M_4C_1).

4.1.7 Interaction effect of germination methods, temperature and seed treatment on germination, root and shoot length.

The data regarding effect of interaction between germination methods, temperature and seed treatments on germination, root and shoot lengths are presented in the Table 7.

4.1.7.1 Interaction effect of germination methods, temperature and seed treatments on germination (%)

The data regarding effect of interaction between germination methods, temperature and seed treatments on

germination are presented in the Table 7. From the data it was revealed that the interaction of germination methods, temperature and seed treatments shows significant effect on germination. The interaction of germination in sand kept at $30 \pm 2^{\circ}\text{C}$ and seed treated with 2% KNO_3 ($\text{M}_2\text{C}_3\text{T}_7$) showed significantly higher germination (57.5 %) than the rest of interactions followed by the interaction of germination in sand kept at $25 \pm 2^{\circ}\text{C}$ and seed treated with 2% KNO_3 ($\text{M}_2\text{C}_2\text{T}_7$) (52.5 %). No germination was observed in the interaction of germination in cocopeat method kept at $20 \pm 2^{\circ}\text{C}$ and kept for stratification ($\text{M}_4\text{C}_1\text{T}_{11}$).

4.1.7.2 Interaction effect of germination methods, temperature and seed treatments on root length (cm)

From the data it was revealed that the interaction of germination methods, temperature and seed treatments showed significant effect on root length. The interaction of germination in sand kept at $30 \pm 2^{\circ}\text{C}$ and seed treated with 2% KNO_3 ($\text{M}_2\text{C}_3\text{T}_7$) showed significantly higher root length (5.37 cm) followed by the interaction of germination in sand kept at $25 \pm 2^{\circ}\text{C}$ and seed treated with 2% KNO_3 ($\text{M}_2\text{C}_2\text{T}_7$) (5.25 cm). Lower root length was observed in the interaction of germination in cocopeat method at $20 \pm 2^{\circ}\text{C}$ with untreated seeds were kept for germination ($\text{M}_4\text{C}_1\text{T}_1$).

4.1.7.3 Interaction effect of germination methods, temperature and seed treatments on shoot length (cm)

From the data it was seen that the interaction of germination methods, temperature and seed treatments

showed significant effect on shoot length. The interaction of germination in sand kept at $25 \pm 2^{\circ}\text{C}$ and seed treated with 2% KNO_3 ($\text{M}_2\text{C}_3\text{T}_7$) showed significantly higher shoot length (8.72 cm) followed by interaction of germination in sand kept at $25 \pm 2^{\circ}\text{C}$ and seed treated 2% KNO_3 ($\text{M}_2\text{C}_2\text{T}_7$) (8.35 cm). Lower shoot length was observed in the interaction of germination in cocopeat kept at $20 \pm 2^{\circ}\text{C}$ and seed treated with cow urine ($\text{M}_4\text{C}_1\text{T}_9$).

Table 7 Interaction effect of germination methods, temperature and seed treatments on germination, root and shoot length.

Treatment combination	Germination (%)	Root length (cm)	Shoot length (cm)
M1C1T1	12 (20.27)*	1.62	5.46
M1C1T2	24 (29.31)	1.86	5.61
M1C1T3	19 (25.78)	1.57	5.62
M1C1T4	10 (18.43)	1.63	5.30
M1C1T5	23 (28.65)	1.82	5.72
M1C1T6	25 (29.96)	1.98	6.17
M1C1T7	30 (33.21)	1.90	7.11
M1C1T8	17 (24.27)	1.57	5.51
M1C1T9	13 (21.12)	1.51	5.30
M1C1T10	14 (21.77)	1.36	5.45
M1C1T11	9 (17.43)	1.51	5.21
M1C1T12	13 (21.12)	1.52	5.43
M1C2T1	13 (21.12)	1.74	5.65
M1C2T2	29 (32.55)	2.00	6.89
M1C2T3	22 (27.95)	1.83	5.83

Table 7 continued.....

Treatment combination	Germination (%)	Root length (cm)	Shoot length (cm)
M1C2T4	13 (21.12)	1.69	5.39
M1C2T5	24 (29.31)	1.93	6.26
M1C2T6	29 (32.55)	2.01	6.87
M1C2T7	33 (35.06)	2.08	7.82
M1C2T8	22 (27.97)	1.91	6.25
M1C2T9	13 (21.12)	1.42	5.44
M1C2T10	17 (24.27)	1.70	5.61
M1C2T11	11 (19.35)	1.32	5.33
M1C2T12	14 (21.92)	1.80	5.70
M1C3T1	17 (24.34)	1.68	5.81
M1C3T2	35 (36.27)	2.05	7.02
M1C3T3	27 (31.30)	1.97	6.78
M1C3T4	15 (22.78)	1.86	5.49
M1C3T5	31 (33.83)	2.01	7.07
M1C3T6	34 (35.67)	2.10	7.64
M1C3T7	37 (37.46)	2.24	7.89
M1C3T8	26 (30.64)	2.01	7.03
M1C3T9	16 (23.54)	1.58	5.48
M1C3T10	23 (28.65)	1.84	6.02
M1C3T11	12 (20.27)	1.45	5.42
M1C3T12	16 (23.54)	1.94	6.05
M2C1T1	22.5 (28.28)	2.52	7.21
M2C1T2	30 (33.14)	3.22	8.07
M2C1T3	17.5 (24.68)	2.96	7.70

Table 7 continued.....

Treatment combination	Germination (%)	Root length (cm)	Shoot length (cm)
M2C1T4	12.5 (20.61)	2.44	7.34
M2C1T5	25 (30.00)	3.10	7.72
M2C1T6	32.5 (34.74)	4.23	8.10
M2C1T7	42.5 (40.68)	4.99	8.17
M2C1T8	30 (33.14)	2.98	7.71
M2C1T9	22.5 (28.00)	2.15	7.13
M2C1T10	25 (29.89)	2.80	7.35
M2C1T11	20 (26.57)	2.08	6.91
M2C1T12	27.5 (31.61)	2.59	7.34
M2C2T1	30 (33.21)	3.01	7.42
M2C2T2	40 (39.23)	4.84	8.26
M2C2T3	27.5 (31.61)	4.52	7.80
M2C2T4	20 (26.57)	2.86	7.58
M2C2T5	40 (39.23)	3.93	7.91
M2C2T6	45 (42.13)	4.87	8.18
M2C2T7	52.5 (46.43)	5.37	8.35
M2C2T8	37.5 (37.75)	3.90	7.93
M2C2T9	30 (33.14)	2.89	7.31
M2C2T10	32.5 (34.74)	2.96	7.55
M2C2T11	30 (33.21)	2.82	7.10
M2C2T12	35 (36.27)	2.97	7.70
M2C3T1	32.5 (34.74)	3.01	7.59
M2C3T2	47.5 (43.57)	4.91	8.40
M2C3T3	37.5 (37.75)	4.76	8.06

Table 7 continued.....

Treatment combination	Germination (%)	Root length (cm)	Shoot length (cm)
M2C3T4	27.5 (31.61)	2.98	7.82
M2C3T5	42.5 (40.68)	4.92	8.21
M2C3T6	50 (45.00)	5.12	8.46
M2C3T7	57.5 (49.32)	5.37	8.72
M2C3T8	35 (36.22)	4.88	8.17
M2C3T9	45 (42.12)	2.93	7.44
M2C3T10	40 (39.20)	4.60	7.87
M2C3T11	27.5 (31.61)	2.88	7.25
M2C3T12	37.5 (37.75)	4.29	8.07
M3C1T1	10 (18.43)	1.49	4.18
M3C1T2	15 (22.79)	1.62	4.48
M3C1T3	15 (22.79)	1.51	4.32
M3C1T4	7.5 (15.68)	1.21	4.10
M3C1T5	15 (22.79)	1.72	4.42
M3C1T6	22.5 (28.28)	1.83	5.02
M3C1T7	32.5 (34.74)	2.08	5.76
M3C1T8	17.5 (24.68)	1.45	4.89
M3C1T9	12.5 (20.61)	1.30	4.18
M3C1T10	22.5 (28.28)	1.51	4.31
M3C1T11	15 (22.79)	1.17	4.15
M3C1T12	15 (22.79)	1.47	4.43
M3C2T1	15 (22.79)	1.71	4.58
M3C2T2	25 (30.00)	1.90	6.21
M3C2T3	17.5 (24.68)	1.81	5.89

Table 7 continued.....

Treatment combination	Germination (%)	Root length (cm)	Shoot length (cm)
M3C2T4	10 (18.43)	1.48	4.43
M3C2T5	20 (26.57)	1.92	6.06
M3C2T6	27.5 (31.61)	2.08	6.38
M3C2T7	35 (36.27)	2.27	6.72
M3C2T8	22.5 (28.28)	1.73	5.37
M3C2T9	17.5 (24.68)	1.58	4.50
M3C2T10	22.5 (28.00)	1.72	5.22
M3C2T11	17.5 (24.68)	1.39	4.60
M3C2T12	20 (26.57)	1.71	4.76
M3C3T1	20 (26.57)	1.79	4.72
M3C3T2	32.5 (34.74)	2.00	6.28
M3C3T3	22.5 (28.28)	1.87	6.18
M3C3T4	17.5 (24.68)	1.72	4.58
M3C3T5	25 (30.00)	2.13	6.37
M3C3T6	32.5 (34.74)	2.22	6.56
M3C3T7	40 (39.23)	2.38	6.95
M3C3T8	27.5 (31.61)	1.80	5.93
M3C3T9	22.5 (28.28)	1.70	4.57
M3C3T10	30 (33.14)	1.78	4.89
M3C3T11	22.5 (28.28)	1.58	4.35
M3C3T12	25 (30.00)	1.80	4.84
M4C1T1	7.5 (15.68)	1.18	4.29
M4C1T2	12.5 (20.61)	1.48	4.68
M4C1T3	5 (12.92)	1.28	4.35

Table 7 continued.....

Treatment combination	Germination (%)	Root length (cm)	Shoot length (cm)
M4C1T4	0 (0.00)	0.00	0.00
M4C1T5	12.5 (20.61)	1.35	4.49
M4C1T6	17.5 (24.68)	1.60	4.74
M4C1T7	27.5 (31.61)	1.91	4.89
M4C1T8	20 (26.57)	1.48	4.36
M4C1T9	10 (18.43)	1.20	2.11
M4C1T10	5 (9.22)	1.31	4.27
M4C1T11	0 (0.00)	0.00	0.00
M4C1T12	0 (0.00)	0.00	0.00
M4C2T1	15 (22.79)	1.57	4.66
M4C2T2	20 (26.57)	1.72	4.93
M4C2T3	12.5 (20.61)	1.66	4.64
M4C2T4	5 (12.92)	1.52	4.42
M4C2T5	20 (26.57)	1.65	4.67
M4C2T6	32.5 (34.74)	1.73	5.08
M4C2T7	37.5 (37.75)	1.86	5.32
M4C2T8	25 (30.00)	1.98	4.69
M4C2T9	20 (26.57)	1.57	4.49
M4C2T10	20 (26.57)	1.45	4.42
M4C2T11	5 (12.92)	1.45	4.30
M4C2T12	10 (18.43)	1.35	4.56
M4C3T1	22.5 (28.28)	1.57	4.56
M4C3T2	32.5 (34.74)	1.82	5.16
M4C3T3	25 (30.00)	2.03	4.67

Table 7 continued.....

Treatment combination	Germination (%)	Root length (cm)	Shoot length (cm)
M4C3T4	17.5 (24.68)	1.69	4.69
M4C3T5	30 (33.21)	1.78	4.95
M4C3T6	35 (36.27)	2.00	5.28
M4C3T7	40 (39.23)	2.21	5.63
M4C3T8	22.5 (28.28)	2.10	4.85
M4C3T9	30 (33.14)	1.75	4.32
M4C3T10	30 (33.21)	1.67	4.66
M4C3T11	17.5 (24.68)	1.49	4.30
M4C3T12	27.5 (31.61)	1.46	4.72
SE $\pm$	1.755	0.173	0.300
CD @ 5%	4.906	0.483	0.873

*Figures in parentheses indicate arcsine transformed values

4.1.8 Effect of seed treatment on seedling dry weight vigour, index-I and vigour index-II

The data regarding effect of seed treatment on seedling dry weight, vigour index-I and vigour index-II are presented in Table 8.

4.1.8.1 Effect of seed treatment on seedling dry weight (mg)

It was evident from the data that the seedling dry weight was differed significantly due to different seed treatments. Among the treatments, 2% KNO₃ (T₇) had the higher seedling dry weight (238.33 mg) than other treatments, followed by 1% KNO₃ (221.67 mg) (T₆). The cold stratification recorded lowest seedling dry weight (141.67 mg) (T₁₁).

Table 8 Effect of seed treatment on seedling dry weight, vigour index-I and vigour index-II

Treatments	Seedling dry weight (mg)	Vigour index-I	Vigour index-II
T1: Control	167.08	140.50	3.12
T2: conc. H ₂ SO ₄ (3min)	194.17	264.34	5.83
T3: conc. H ₂ SO ₄ (5min)	172.50	181.95	3.80
T4: conc. H ₂ SO ₄ (10min)	161.25	113.58	2.37
T5: 1% KH ₂ PO ₄	196.67	229.34	5.26
T6: 1% KNO ₃	221.67	300.84	7.28
T7: 2% KNO ₃	238.33	383.92	9.44
T8: 0.5% Thiourea	178.75	217.27	4.69
T9: Cow urine	147.92	154.02	3.31
T10: Mechanical scarification	167.50	186.68	4.12
T11: Stratification	141.67	101.97	2.24
T12: Water soaking	172.50	163.08	3.63
SE ±	4.79	6.789	0.185
CD @ 5%	13.38	18.977	0.517

4.1.8.2 Effect of seed treatment on vigour index-I

It was revealed that vigour index-I was statistically significant due to different seed treatment. It was seen that 2% KNO₃ treatment (T₇) had the higher vigour index-I (383.92) followed by 1% KNO₃ treatment (T₆) (300.84). Where, as lowest vigour index-I was seen when seed kept at cold stratification (101.97) (T₁₁).

4.1.8.3. Effect of seed treatment on vigour index-II

It was evident that the data on vigour index-II was significantly differed due to different seed treatments. Among the treatments, 2% KNO₃ (T₇) had the higher vigour index-II

(9.44), followed by 1% KNO₃ (7.28) (T6). The cold stratification recorded lowest vigour index-II (2.24) (T₁₁).

4.1.9 Effect of germination methods on seedling dry weight, vigour index-I and vigour index-II

The data regarding effect of germination method on seedling dry weight, vigour index-I and vigour index-II are presented in Table 9

4.1.9.1 Effect of germination methods on seedling dry weight (mg)

It was noticed from the Table 9 that, there were significant differences in seedling dry weight due to different germination methods. The higher seedling dry weight (207.36 mg) was recorded in sand method (M₂) followed by between paper method (M₁) (194.17 mg). The cocopeat method recorded the lowest seedling dry weight (150.97 mg).

4.1.9.2 Effect of germination methods on vigour index-I

The data regarding vigour index-I are presented in the Table 9 from the table, it was noticed that differences in vigour index-I was statistically significant due to different germination methods. The higher vigour index-I (325.70) was recorded in sand methods (M₂) followed by between paper method (M₁) (212.88). Where, as the lowest vigour index-I (120.38) was noticed in cocopeat method (M₄).

4.1.9.3 Effect of germination methods on vigour index-II

It was noticed from the Table 9 that, there were significant differences in vigour index-II due to different germination methods. The higher vigour index-II (7.27) was recorded in sand method (M₂) followed by between paper

method (M₁) (4.14). Where, as the lowest vigour index-II (3.12) was noticed in cocopeat (M₄).

Table 9 Effect of germination methods on seedling dry weight, vigour index-I and vigour index-II

Germination methods	Seedling dry weight (mg)	Vigour index-I	Vigour index-II
M1: Between paper	194.17	212.88	4.14
M2: Sand method	207.36	325.70	7.27
M3: Top of paper	167.50	153.56	3.83
M4: Cocopeat	150.97	120.38	3.12
SE $\pm$	2.7	1.23	0.106
CD @ 5%	7.72	3.51	0.298

4.1.10 Effect of temperature on seedling dry weight, vigour index-I and vigour index-II

The data on effect of temperature on seedling dry weight, vigour index-I and vigour index-II presented in the Table 10.

4.1.10.1 Effect of temperature on seedling dry weight (mg)

It was revealed that temperature had significant effect on seedling dry weight. The higher seedling dry weight was recorded at the $30 \pm 2^{\circ}\text{C}$ temperature (C₃) (197.81 mg) followed by $25 \pm 2^{\circ}\text{C}$ temperature (C₂) (188.43 mg). The lowest seedling dry weight (153.75 mg) was recorded at $20 \pm 2^{\circ}\text{C}$ temperature (C₁).

4.1.10.2 Effect of temperature on vigour index-I

The data regarding effect of temperature on vigour index-I is presented in the Table 10.

The data revealed that differences in vigour index-I was statistically significant due to different temperature. The higher vigour index-I (264.25) was recorded at $30 \pm 2^{\circ}\text{C}$ temperature (C₃) followed by $25 \pm 2^{\circ}\text{C}$ temperature (C₂)

(205.27). Where, as the lowest vigour index-I (139.85) was recorded at $20 \pm 2^{\circ}\text{C}$ temperature (C_1).

Table 10 Effect of temperature on seedling dry weight, vigour index-I and vigour index-II

Temperature	Seedling dry weight (mg)	Vigour index-I	Vigour index-II
C1: $20 \pm 2^{\circ}\text{C}$	153.75	139.85	2.95
C2: $25 \pm 2^{\circ}\text{C}$	188.43	205.27	4.74
C3: $30 \pm 2^{\circ}\text{C}$	197.81	264.25	6.08
SE $\pm$	2.394	3.394	0.092
CD @ 5%	6.691	9.488	0.258

4.1.10.3 Effect of temperature on vigour index-II

It was clear from the Table 10, that there were significant differences in vigour index-II due to different temperature. The higher vigour index-II (6.08) was recorded at $30 \pm 2^{\circ}\text{C}$ temperature (C_3) followed by $25 \pm 2^{\circ}\text{C}$ temperature (C_2) (4.74). Where, as the lowest vigour index-II (2.95) was noticed at $20 \pm 2^{\circ}\text{C}$ temperature (C_1).

4.1.11 Interaction effect of germination methods and seed treatments on seedling dry weight, vigour index-I and vigour index-II

The data regarding interaction effect of germination methods and seed treatments on seedling dry weight, vigour index-I and vigour index-II are presented below in Table 11.

4.1.11.1 Interaction effect of germination methods and seed treatments on seedling dry weight (mg)

The data on interaction effect of germination methods and treatments on seedling dry weight are presented in the table 11.

It was observed that the interactions of germination methods and seed treatments had significant effect on seedling dry weight. The interaction of germination in sand and seed treated with 2%

Table.11 Interaction effect of germination methods and seed treatments on seedling dry weight, vigour index-I and vigour index-II

Treatment combination	Seedling dry weight (mg)	Vigour index-I	Vigour index-II
M1T1	186.67	119.38	2.62
M1T2	205.00	323.61	6.05
M1T3	193.33	234.61	4.40
M1T4	171.67	103.69	2.19
M1T5	205.00	273.86	5.33
M1T6	216.67	345.59	6.41
M1T7	240.00	429.89	8.03
M1T8	196.67	225.93	4.29
M1T9	171.67	113.24	2.42
M1T10	190.00	169.18	3.47
M1T11	161.67	84.96	1.73
M1T12	191.67	130.69	2.75
M2T1	176.67	258.63	5.14
M2T2	231.67	401.08	9.16
M2T3	203.33	267.61	5.78
M2T4	193.33	187.58	3.99
M2T5	221.67	355.39	8.07
M2T6	250.00	438.13	10.66
M2T7	266.67	535.52	13.67
M2T8	226.67	334.83	7.79
M2T9	165.00	289.02	5.55
M2T10	196.67	302.86	6.53
M2T11	155.00	220.11	4.09
M2T12	203.33	317.62	6.87
M3T1	148.33	93.69	2.29
M3T2	181.67	187.61	4.52
M3T3	161.67	134.11	3.00
M3T4	131.67	69.63	1.59
M3T5	180.00	154.71	3.69

Table 11 continued.....

Treatment combination	Seedling dry weight (mg)	Vigour index-I	Vigour index-II
M3T6	211.67	224.32	5.95
M3T74	248.33	314.27	9.04
M3T8	165.00	161.81	3.80
M3T9	136.67	105.52	2.50
M3T10	156.67	163.28	3.95
M3T11	136.67	105.94	2.61
M3T12	150.00	127.83	3.01
M4T1	156.67	90.31	2.42
M4T2	158.33	145.07	3.60
M4T3	131.67	91.50	2.03
M4T4	148.33	47.00	1.22
M4T5	180.00	133.43	3.95
M4T6	210.00	195.36	6.12
M4T7	196.67	256.03	7.01
M4T8	126.67	146.53	2.90
M4T9	118.33	108.34	2.76
M4T10	126.67	111.43	2.51
M4T11	113.33	43.33	1.06
M4T12	145.00	76.21	1.89
SE $\pm$	9.574	13.577	0.370
CD @ 5%	26.763	37.953	1.035

KNO₃ (M₂T₇) showed significantly higher dry weight (266.67 mg) followed by interaction of germination in sand and seed treated with 1% KNO₃ (M₂T₇) (250.00 mg). The lowest seedling dry weight (113.33 mg) was observed in the interaction of germination in cocopeat and seed kept for stratification (M₄T₁₁).

4.1.11.2 Interaction effect of germination methods and seed treatments on vigour index-I

The data regarding interaction effect of germination methods and seed treatments had significant effect on vigour index-I. However, the interaction of germination in sand and seed treated with 2% KNO₃ (M₂T₇) showed significantly higher vigour index-I (535.52) followed by the interaction of

germination in sand and seed treated with 1% KNO_3 (M_2T_6) (438.13). The lowest vigour index-I (43.33) was observed in the interaction of germination in cocopeat and seed kept for stratification (M_4T_{11}).

4.1.11.3 Interaction effect of germination methods and seed treatments on vigour index-II

The data on interaction effect of germination methods and treatments on vigour index-II are presented in the Table 11. It was observed that the interactions of germination methods and treatments had significant effect on vigour index-II. The interaction of germination in sand and seed treated with 2% KNO_3 (M_2T_7) showed significantly higher vigour index-II (13.67) followed by the interaction of germination in sand and seed treated with 1% KNO_3 (M_2T_6) (10.66). The lowest vigour index-II (1.06) was observed in the interaction of germination in cocopeat and seed kept for stratification (M_4T_{11}).

4.1.12 Interaction effect of temperature and seed treatments on seedling dry weight, vigour index-I and vigour index-II

Two factor interaction effect of temperature and seed treatments on seedling dry weight, vigour index-I and vigour index-II are presented in the Table 12.

4.1.12.1 Interaction effect of temperature and treatments on seedling dry weight (mg)

The data on interaction effect of temperature and treatments on seedling dry weight are presented in the Table 12. It was observed that the interactions of temperature and treatments had significant effect on seedling dry weight. The

interaction of $30 \pm 2^{\circ}\text{C}$ temperature and seed treated with 2% KNO_3 (C_3T_7) showed significantly higher seedling dry weight (256.25 mg) followed by the interaction of $25 \pm 2^{\circ}\text{C}$ temperature and seed treated with 2% KNO_3 (C_2T_7) (246.25 mg). The lowest seedling dry weight (108.75 mg) was observed in the interaction of $20 \pm 2^{\circ}\text{C}$ temperature and seed kept for stratification (C_1T_{11}).

4.1.12.2 Interaction effect of temperature and seed treatments on vigour index-I

The data regarding interaction effect of temperature and seed treatments had significant effect on vigour index-I. The interaction of temperature $30 \pm 2^{\circ}\text{C}$ and seed treated with 2% KNO_3 (C_3T_7) showed significantly highest vigour index-I (452.03) followed by the interaction of $25 \pm 2^{\circ}\text{C}$ temperature and seed treated with 2% KNO_3 (C_2T_7) (391.44). The lowest vigour index-I (57.04) was observed in the interaction of $20 \pm 2^{\circ}\text{C}$ temperature and seed kept for stratification (C_1T_{11}).

4.1.12.3 Interaction effect of temperature and seed treatments on vigour index-II

The data on Interaction effect of temperature and seed treatments on vigour index-II are presented in the Table 12. It was observed that the interactions of temperature and seed treatments had significant effect on vigour index-II. However, when seed treated with 2% KNO_3 and kept at $30 \pm 2^{\circ}\text{C}$ temperature (C_3T_7) showed significantly higher vigour index-II (11.32) than the rest of interactions. The lowest vigour index-II (1.11) was observed when seed kept for stratification at $30 \pm 2^{\circ}\text{C}$ temperature (C_1T_{11}).

Table 12 Interaction effect of temperature and treatments on seedling dry weight, vigour index-I and vigour index-II

Treatment combination	Seedling dry weight (mg)	Vigour index-I	Vigour index-II
C1T1	141.25	98.21	1.82
C1T2	171.25	169.39	3.71
C1T3	147.50	110.19	2.25
C1T4	137.50	78.50	1.34
C1T5	175.00	151.38	3.44
C1T6	196.25	213.67	4.91
C1T7	212.50	308.31	7.20
C1T8	145.00	162.69	3.16
C1T9	115.00	96.23	1.76
C1T10	143.75	123.30	2.53
C1T11	108.75	57.04	1.11
C1T12	151.25	109.36	2.22
C2T1	173.75	143.73	3.20
C2T2	202.50	271.52	5.95
C2T3	182.50	176.69	3.78
C2T4	166.25	95.26	2.08
C2T5	197.50	231.66	5.27
C2T6	225.00	313.43	7.62
C2T7	246.25	391.44	9.80
C2T8	188.75	230.03	5.18
C2T9	155.00	149.73	3.15
C2T10	177.50	180.64	4.19
C2T11	151.25	118.72	2.48
C2T12	195.00	160.52	4.12
C3T1	186.25	179.57	4.32
C3T2	208.75	352.12	7.84
C3T3	187.50	258.99	5.38
C3T4	180.00	153.62	3.54
C3T5	217.50	305.01	7.07
C3T6	243.75	375.44	9.32
C3T7	256.25	452.03	11.32
C3T8	202.50	259.11	5.74
C3T9	173.75	216.12	5.01
C3T10	181.25	256.13	5.64
C3T11	165.00	143.54	3.30
C3T12	171.25	219.39	4.55
SE $\pm$	8.292	11.758	0.320
CD @ 5%	23.876	32.868	0.896

4.1.13. Interaction effect of germination methods and temperature on seedling dry weight, vigour index-I and vigour index-II

The data regarding effect of interaction between germination method and temperature on seedling dry weight, vigour index-I and vigour index-II are presented in the Table 13.

4.1.13.1 Interaction effect of germination methods and temperature on seedling dry weight (mg)

The data on interaction effect of germination methods and temperature on seedling dry weight are presented in the Table 13. It was observed that the interactions of germination methods and temperature had significant effect on seedling dry weight. The interaction of germination in sand and kept at $30 \pm 2^{\circ}\text{C}$ (M_2C_3) showed significantly higher seedling dry weight (226.25 mg) than the rest of interactions followed by interaction of germination in sand and kept at $25 \pm 2^{\circ}\text{C}$ (M_2C_2) (215.83 mg). The lowest seedling dry weight (113.33 mg) was observed in the interaction of germination in cocopeat and kept at $20 \pm 2^{\circ}\text{C}$ (M_4C_1).

4.1.13.2 Interaction effect of germination methods and temperature on vigour index-I

The data on interaction effect of germination methods and temperature on vigour index-I are presented in the Table 13. It was evident that the interactions of germination methods and temperature had significant effect on vigour index-I. The interaction of germination in sand kept at $30 \pm 2^{\circ}\text{C}$ (M_2C_3) showed significantly higher vigour index-I (400.20) followed by interaction of germination in sand kept at $25 \pm 2^{\circ}\text{C}$

(M₂C₂) (337.69). The lowest vigour index-I (56.82) was observed in the interaction of germination in cocopeat and kept at $20 \pm 2^{\circ}\text{C}$ (M₄C₁).

4.1.13.3 Interaction effect of germination method and temperature on vigour index-II

The data on interaction effect of germination method and temperature on vigour index-II are presented in the Table 13. It was evident that the interactions of germination methods and temperature had significant effect on vigour index-II. The interaction of germination in sand and kept at $30 \pm 2^{\circ}\text{C}$ for germination (M₂C₃) showed significantly higher vigour index-II (9.26), followed by interaction of germination in sand and kept at $25 \pm 2^{\circ}\text{C}$ for germination (M₂C₂) (7.75). The lowest vigour index-II (5.68) was observed in the interaction of germination in cocopeat kept at $20 \pm 2^{\circ}\text{C}$ (M₄C₁).

Table 13 Interaction effect germination method and temperature on seedling dry weight, vigour index-I and vigour index-II

Treatment combination	Seedling dry weight (mg)	Vigour index-I	Vigour index-II
M1C1	185.83	158.75	3.37
M1C2	193.75	208.51	4.02
M1C3	202.92	271.39	5.03
M2C1	180.00	239.20	4.82
M2C2	215.83	337.69	7.75
M2C3	226.25	400.20	9.26
M3C1	135.83	104.65	2.40
M3C2	180.42	154.74	3.97
M3C3	186.25	201.29	5.12
M4C1	113.33	56.82	1.23
M4C2	163.75	120.18	3.21
M4C3	175.83	184.13	4.93
SE $\pm$	4.787	6.789	0.185
CD @ 5%	13.381	18.977	0.517

4.1.14 Interaction effect of media, temperature and treatments on seedling dry weight, vigour index-I and vigour index-II

The data regarding on interaction effect of media, temperature and treatments on seedling dry weight, vigour index-I and vigour index-II are presented in Table 14.

4.1.14.1 Interaction effect of media, temperature and seed treatments on seedling dry weight (mg)

From the Table 14, it was revealed that the data on interaction of germination methods, temperature and treatments showed significant effect on seedling dry weight. The interaction of germination in sand kept at $30 \pm 2^{\circ}\text{C}$ temperature and seed treated with 2% KNO_3 ($\text{M}_2\text{C}_3\text{T}_7$) showed significantly highest seedling dry weight (285.00 mg) followed by the interaction of germination in sand kept at $25 \pm 2^{\circ}\text{C}$ and seed treated with 2% KNO_3 ($\text{M}_2\text{C}_2\text{T}_7$) (275.00 mg). Lower seedling dry weight was observed in the interaction of germination in cocopeat and seed treated with cow urine kept ($\text{M}_4\text{C}_1\text{T}_9$) at $20 \pm 2^{\circ}\text{C}$ temperature.

4.1.14.2 Interaction effect of media, temperature and seed treatments on vigour index-I

The data regarding interaction effect of media, temperature and seed treatments had significant effect on vigour index-I. The interaction of germination in sand kept at $30 \pm 2^{\circ}\text{C}$ temperature and seed treated with 2% KNO_3 ($\text{M}_2\text{C}_3\text{T}_7$) showed significantly highest vigour index-I (630.58) than the rest of interactions followed by the interaction of germination in sand kept at $25 \pm 2^{\circ}\text{C}$ and seed treated with 2% KNO_3 ($\text{M}_2\text{C}_3\text{T}_7$) (528.00). Lower vigour index-I was observed

in the interaction of germination in cocopeat and seed treated with cow urine kept (M₄C₁T₉) at 20 ± 2°C temperature.

Table 14 Interaction effect of media, temperature and treatments on seedling dry weight, vigour index-I and vigour index-II

Treatment combination	Seedling dry weight (mg)	Vigour index-I	Vigour index-II
M1C1T1	180.00	95.70	2.16
M1C1T2	195.00	212.74	4.69
M1CT3	185.00	163.56	3.53
M1C1T4	160.00	77.30	1.60
M1C1T5	210.00	202.98	4.82
M1C1T6	205.00	261.62	5.14
M1C1T7	230.00	362.85	6.90
M1C1T8	190.00	144.44	3.23
M1C1T9	160.00	96.48	2.07
M1C1T10	180.00	116.69	2.56
M1C1T11	150.00	65.98	1.37
M1C1T12	185.00	104.64	2.42
M1C2T1	185.00	112.68	2.41
M1C2T2	210.00	340.46	6.12
M1C2T3	200.00	228.82	4.42
M1C2T4	170.00	106.96	2.20
M1C2T5	195.00	247.34	4.69
M1C2T6	215.00	341.48	6.28
M1C2T7	240.00	435.66	7.93
M1C2T8	190.00	223.30	4.18
M1C2T9	170.00	108.38	2.22
M1C2T10	190.00	146.25	3.26
M1C2T11	165.00	89.36	1.80
M1C2T12	195.00	121.44	2.74
M1C3T1	195.00	149.75	3.31
M1C3T2	210.00	417.63	7.36
M1C3T3	195.00	311.45	5.26
M1C3T4	185.00	126.81	2.77
M1C3T5	210.00	371.25	6.50
M1C3T6	230.00	433.67	7.82
M1C3T7	250.00	491.15	9.26
M1C3T8	210.00	310.04	5.46
M1C3T9	185.00	134.85	2.97
M1C3T10	200.00	244.60	4.61
M1C3T11	170.00	99.54	2.04
M1C3T12	195.00	165.99	3.11
M2C1T1	135.00	199.95	3.05
M2C1T2	210.00	296.95	6.25
M2C1T3	175.00	161.60	3.05
M2C1T4	165.00	110.93	2.05
M2C1T5	200.00	238.25	5.00
M2C1T6	230.00	327.83	7.50
M2C1T7	250.00	428.13	10.65
M2C1T8	200.00	278.25	5.95
M2C1T9	135.00	197.40	3.07

Table 14 continued.....

Treatment combination	Seedling dry weight (mg)	Vigour index-I	Vigour index-II
M2C1T10	170.00	218.45	4.25
M2C1T11	125.00	168.30	2.50
M2C1T12	165.00	244.38	4.52
M2C2T1	185.00	274.65	5.55
M2C2T2	235.00	410.00	9.40
M2C2T3	210.00	265.25	5.80
M2C2T4	200.00	185.30	4.00
M2C2T5	225.00	393.40	9.00
M2C2T6	250.00	458.55	11.25
M2C2T7	275.00	547.85	13.95
M2C2T8	230.00	369.05	8.62
M2C2T9	175.00	262.85	5.22
M2C2T10	205.00	300.58	6.67
M2C2T11	165.00	252.45	4.95
M2C2T12	245.00	332.33	8.57
M2C3T1	210.00	301.28	6.82
M2C3T2	250.00	496.30	11.85
M2C3T3	225.00	375.98	8.50
M2C3T4	215.00	266.50	5.92
M2C3T5	240.00	434.53	10.22
M2C3T6	265.00	528.00	13.25
M2C3T7	285.00	630.58	16.42
M2C3T8	250.00	357.20	8.80
M2C3T9	185.00	406.80	8.35
M2C3T10	215.00	389.55	8.67
M2C3T11	175.00	239.58	4.82
M2C3T12	200.00	376.15	7.52
M3C1T1	120.00	56.60	1.20
M3C1T2	150.00	91.35	2.25
M3C1T3	130.00	87.45	1.95
M3C1T4	110.00	39.95	8.25
M3C1T5	150.00	92.03	2.25
M3C1T6	175.00	154.23	3.92
M3C1T7	205.00	255.33	6.67
M3C1T8	125.00	111.25	2.17
M3C1T9	110.00	68.55	1.37
M3C1T10	125.00	130.90	2.82
M3C1T11	100.00	79.73	1.50
M3C1T12	130.00	88.43	1.95
M3C2T1	165.00	94.28	2.47
M3C2T2	200.00	202.63	5.00
M3C2T3	175.00	133.83	3.05
M3C2T4	135.00	59.10	1.35
M3C2T5	185.00	159.60	3.70
M3C2T6	215.00	233.25	5.92
M3C2T7	270.00	314.48	9.45
M3C2T8	180.00	161.13	4.07
M3C2T9	135.00	106.70	2.37
M3C2T10	180.00	158.33	4.12
M3C2T11	145.00	104.33	2.55
M3C2T12	180.00	129.20	3.60
M3C3T1	160.00	130.20	3.20
M3C3T2	195.00	268.85	6.32
M3C3T3	180.00	181.05	4.02
M3C3T4	150.00	109.83	2.60

Table 14 continued.....

Treatment combination	Seedling dry weight (mg)	Vigour index-I	Vigour index-II
M3C3T5	205.00	212.50	5.12
M3C3T6	245.00	285.48	8.00
M3C3T7	265.00	373.00	11.00
M3C3T8	190.00	213.05	5.17
M3C3T9	165.00	141.30	3.77
M3C3T10	165.00	200.60	4.92
M3C3T11	165.00	133.78	3.80
M3C3T12	140.00	165.88	3.50
M4C1T1	130.00	40.58	9.00
M4C1T2	130.00	76.50	1.65
M4C1T3	100.00	28.15	5.00
M4C1T4	0.00	0.00	0.00
M4C1T5	140.00	72.25	1.72
M4C1T6	175.00	111.00	3.10
M4C1T7	165.00	186.93	4.57
M4C1T8	65.00	116.80	1.30
M4C1T9	55.00	22.50	5.50
M4C1T10	100.00	27.15	5.00
M4C1T11	0.00	0.00	0.00
M4C1T12	0.00	0.00	0.00
M4C2T1	160.00	93.30	2.40
M4C2T2	165.00	133.00	3.30
M4C2T3	145.00	78.85	1.85
M4C2T4	160.00	29.68	8.00
M4C2T5	185.00	126.30	3.70
M4C2T6	220.00	220.45	7.05
M4C2T7	210.00	267.78	7.87
M4C2T8	155.00	166.63	3.87
M4C2T9	140.00	121.00	2.80
M4C2T10	135.00	117.40	2.70
M4C2T11	130.00	28.73	6.50
M4C2T12	160.00	59.10	1.60
M4C3T1	180.00	137.05	3.97
M4C3T2	180.00	225.70	5.85
M4C3T3	150.00	167.50	3.75
M4C3T4	170.00	111.33	2.87
M4C3T5	215.00	201.75	6.45
M4C3T6	235.00	254.63	8.22
M4C3T7	215.00	313.40	8.60
M4C3T8	160.00	156.15	3.55
M4C3T9	160.00	181.53	4.95
M4C3T10	145.00	189.75	4.35
M4CT11	150.00	101.28	2.55
M4CT12	150.00	169.53	4.07
SE $\pm$	16.583	23.517	0.024
CD @ 5%	47.749	69.551	0.073

4.1.15 Effect of seed treatment on electrical conductivity, moisture content, seed mycoflora and seed weight

The data regarding effect of seed treatment on electrical conductivity, moisture content, seed mycoflora and seed weight of sarpgandha are presented in Table 15.

4.1.15.1 Effect of seed treatment on electrical conductivity (dSm^{-1})

It was evident from the data that the electrical conductivity was significantly differed due to different seed treatments. Among the treatment, 2% KNO_3 (T_7) recorded lowest (0.361 dSm^{-1}) electrical conductivity. However cow urine treatment (T_9) had highest electrical conductivity (0.538 dSm^{-1}) than other treatments, followed by control (0.529 dSm^{-1}) (T_1).

4.1.15.2 Effect of seed treatment on moisture content (%)

It was observed from the data that the moisture content was significantly differed due to different seed treatments. Among the treatments, when seed treated with 2% KNO_3 (T_7) recorded lowest (2.48 %) moisture content than other treatments. However cow urine (T_9) had the higher moisture content (2.65 %) followed by control (2.62 %) (T_1).

4.1.15.3 Effect of seed treatments on seed mycoflora (%)

It was observed that different seed treatments had significant effect on seed mycoflora. The mycelium growth was not seen when seed treated with sulfuric acid (0.00) (T_2 T_3 T_4). However, the higher seed mycoflora was seen when seed treated with cow urine (26.50 %) (T_9).

Table 15 Effect of seed treatment on electrical conductivity, moisture content, seed mycoflora and seed weight

Treatments	Electrical conductivity (dSm ⁻¹)	Moisture content (%)	Seed mycoflora (%)	Seed weight (g)
T1: Control	0.529	2.62 (9.32)*	20.00 (26.06)*	3.51
T2: conc. H ₂ SO ₄ 3 min	0.448	2.55 (9.19)	0.00 (0.00)	3.44
T3: conc. H ₂ SO ₄ 5 min	0.483	2.57 (9.23)	0.00 (0.00)	3.47
T4: conc. H ₂ SO ₄ 10 min	0.504	2.59 (9.26)	0.00 (0.00)	3.48
T5: 1% KH ₂ PO ₄	0.445	2.54 (9.18)	11.66 (19.86)	3.44
T6: 1% KNO ₃	0.420	2.49 (9.09)	6.66 (12.27)	3.41
T7: 2% KNO ₃	0.391	2.48 (9.07)	0.00 (0.00)	3.38
T8: 0.5% Thiourea	0.509	2.56 (9.21)	15.00 (22.58)	3.46
T9: Cow urine	0.538	2.65 (9.32)	26.50 (30.82)	3.51
T10: Mechanical scarification	0.493	2.59 (9.27)	20.00 (26.44)	3.49
T11: Stratification	0.518	2.62 (9.31)	25.00 (29.92)	3.51
T12: Water soaking	0.510	2.59 (9.27)	21.66 (27.51)	3.48
SE ±	0.006	0.006	0.177	0.005
CD @ 5%	0.017	0.017	0.496	0.015

*Figures in parentheses indicate arcsine transformed values

4.1.15.4 Effect of seed treatments on seed weight (g)

From the data it was concluded that the seed weight was significantly differed due to different seed treatments. Among

the treatments, 2% KNO₃ (T₇) recorded lowest (3.38 g) seed weight than the other treatments. Cow urine treatment (T₉) had highest seed weight (3.51 g).

4.1.16 Effect of temperature on electrical conductivity, moisture content, seed mycoflora and seed weight

The data on effect of temperatures on electrical conductivity, moisture content, seed mycoflora and seed weight are presented in the Table 16.

4.1.16.1 Effect of temperature on electrical conductivity (dSm⁻¹)

It was revealed that temperature had significant effect on electrical conductivity. The lowest electrical conductivity (0.461 dSm⁻¹) was recorded at $30 \pm 2^{\circ}\text{C}$ temperature (C₃). The highest electrical conductivity was recorded at the $20 \pm 2^{\circ}\text{C}$ temperature (0.505 dSm⁻¹) (C₁).

4.1.16.2 Effect of temperature on moisture content (%)

It was evident that temperature had significant effect on moisture content. The highest moisture content was recorded at the $20 \pm 2^{\circ}\text{C}$ temperature (2.60 %) (C₁), followed by $25 \pm 2^{\circ}\text{C}$ temperature (2.57 %) (C₂). The lowest moisture content (2.55 %) was recorded at $30 \pm 2^{\circ}\text{C}$ temperature (C₃).

Table 16 Effect of temperature on electrical conductivity, moisture content, seed mycoflora and seed weight

Temperature	Electric conductivity (dSm ⁻¹)	Moisture content (%)	Seed mycoflora (%)	Seed weight (g)
C1: 20 ± 2°C	0.505	2.60 (9.27)*	8.29 (12.80)*	3.49
C2: 25 ± 2°C	0.481	2.57 (9.23)	12.50 (16.92)	3.46
C3: 30 ± 2°C	0.461	2.55 (9.19)	15.83 (19.15)	3.45
SE ±	0.003	0.003	0.089	0.003
CD @ 5 %	0.008	0.009	0.248	0.008

*Figures in parentheses indicate arcsine transformed values

4.1.16.3 Effect of temperature on seed mycoflora (%)

It was observed that temperature had significant effect on seed mycoflora. The mycelium growth was decreases with increases in temperature. The lowest seed mycoflora (8.29 %) was observed at 30 ± 2°C temperature (C₃).The highest seed mycoflora was seen at the 30 ± 2°C temperature (15.83 %) (C₁),

4.1.16.4 Effect of temperature on seed weight (g)

It was revealed that temperature had significant effect on seed weight. The lowest seed weight (3.45 g) was recorded at 30 ± 2°C temperature (C₃). The highest seed weight was recorded at the 20 ± 2°C temperature (3.49 g) (C₁).

4.1.17 Interaction effects of temperature and seed treatments on electrical conductivity, moisture content, seed mycoflora and seed weight

The data regarding interaction effect of temperature and treatments on electrical conductivity, moisture content, seed mycoflora and seed weight are presented in the Table 17.

4.1.17.1 Interaction effect of temperature and seed treatment on electrical conductivity (dSm⁻¹)

It was observed from Table 17 that, the interaction of temperature and treatments shows significant effect on electric conductivity. The interaction of temperature $20 \pm 2^\circ\text{C}$ and seed treated with cow urine (C₁T₉) showed significantly highest electrical conductivity (0.558 dSm⁻¹) followed by the interaction of temperature $20 \pm 2^\circ\text{C}$ and seed used as control (0.553 dSm⁻¹) (C₁T₁). The lowest electrical conductivity (0.361 dSm⁻¹) was observed in the interaction of temperature $30 \pm 2^\circ\text{C}$ and seed treated with 2% KNO₃ (C₃T₇).

Table 17 Interaction effects of temperature and seed treatment on electrical conductivity, moisture content, seed mycoflora and seed weight

Treatment combination	Electrical conductivity (dSm ⁻¹)	Moisture content (%)	Seed mycoflora (%)	Seed weight (g)
C1T1	0.553	2.61 (9.33)*	10.00 (18.41)*	3.54
C1T2	0.478	2.56 (9.20)	0.00 (0.00)	3.47
C1T3	0.518	2.59 (9.26)	0.00 (0.00)	3.50
C1T4	0.533	2.60 (9.27)	0.00 (0.00)	3.52
C1T5	0.470	2.55 (9.18)	10.00 (18.41)	3.48
C1T6	0.440	2.49 (9.08)	0.00 (0.00)	3.41
C1T7	0.415	2.49 (9.08)	0.00 (0.00)	3.40
C1T8	0.520	2.57 (9.23)	10.00 (18.41)	3.48
C1T9	0.558	2.61 (9.29)	19.50 (26.20)	3.55
C1T10	0.530	2.61 (9.29)	15.00 (22.78)	3.52
C1T11	0.530	2.63 (9.33)	20.00 (26.56)	3.54

Table 17 continued.....

Treatment combination	Electrical conductivity (dsm ⁻¹)	Moisture content (%)	Seed mycoflora (%)	Seed weight (g)
C1T12	0.518	2.60 (9.28)	15.00 (22.78)	3.50
C2T1	0.528	2.61 (9.30)	20.00 (26.56)	3.52
C2T2	0.445	2.54 (9.16)	0.00 (0.00)	3.44
C2T3	0.480	2.56 (9.20)	0.00 (0.00)	3.47
C2T4	0.498	2.58 (9.25)	0.00 (0.00)	3.48
C2T5	0.453	2.53 (9.15)	10.00 (18.41)	3.43
C2T6	0.418	2.49 (9.08)	10.00 (18.41)	3.40
C2T7	0.398	2.47 (9.04)	0.00 (0.00)	3.39
C2T8	0.520	2.54 (9.17)	20.00 (26.56)	3.47
C2T9	0.538	2.60 (9.28)	25.00 (30.00)	3.51
C2T10	0.460	2.59 (9.26)	20.00 (26.56)	3.49
C2T11	0.515	2.59 (9.25)	25.00 (30.00)	3.51
C2T12	0.518	2.58 (9.24)	20.00 (26.56)	3.48
C3T1	0.508	2.58 (9.24)	30.00 (33.21)	3.47
C3T2	0.420	2.52 (9.13)	0.00 (0.00)	3.44
C3T3	0.453	2.54 (9.16)	0.00 (0.00)	3.45
C3T4	0.483	2.54 (9.17)	0.00 (0.00)	3.45
C3T5	0.413	2.53 (9.16)	15.00 (22.78)	3.42
C3T6	0.403	2.47 (9.04)	10.00 (18.41)	3.38
C3T7	0.361	2.45 (9.00)	0.00 (0.00)	3.38
C3T8	0.486	2.52 (9.14)	15.00 (22.78)	3.45
C3T9	0.519	2.59 (9.25)	35.00 (36.27)	3.49
C3T10	0.488	2.56 (9.21)	25.00 (30.00)	3.48
C3T11	0.508	2.58 (9.24)	30.00 (33.21)	3.49
C3T12	0.495	2.56 (9.20)	30.00 (33.21)	3.48
SE ±	0.011	0.009	0.307	0.008
CD @ 5%	0.031	0.027	0.859	0.024

*Figures in parentheses indicate arcsine transformed values

4.1.17.2 Interaction effect of temperature and seed treatment on moisture content (%)

The data regarding interaction effect of temperature and treatments on moisture content are presented in the Table 17. It was observed that the interactions of temperature and treatments had significant effect on moisture content. The interaction of temperature $30 \pm 2^{\circ}\text{C}$ and seed treated with 2% KNO_3 (C_3T_7) showed significantly lowest moisture content (2.45 %) followed by the interaction of temperature $30 \pm 2^{\circ}\text{C}$ and seed treated with 1% KNO_3 (C_3T_6) (2.47 %). The highest moisture content (2.63 %) was observed in the interaction of temperature $20 \pm 2^{\circ}\text{C}$ and seed were kept at cold stratification (C_1T_{11}).

4.1.17.3 Interaction effect of temperature and seed treatments on seed mycoflora (%).

It was observed that interaction effect of temperature and treatments had significant effect on seed mycoflora. The mycelium growth was not seen at the interaction of temperature $20 \pm 2^{\circ}\text{C}$, $25 \pm 2^{\circ}\text{C}$, $30 \pm 2^{\circ}\text{C}$ and seed treated with conc. H_2SO_4 . The highest mycelium growth was seen at the interaction of temperature $30 \pm 2^{\circ}\text{C}$ and seed treated with cow urine (C_3T_9) (35.00 %)

4.1.17.4 Interaction effect of temperature and seed treatments on seed weight (g)

From the data it was concluded that the interaction effect of temperature and treatments on seed weight was significant. Among the interaction of temperature $30 \pm 2^{\circ}\text{C}$ and seed treated with 2% KNO_3 (C_3T_7) recorded lowest (3.38 g) (C_3T_7) seed weight. However interaction of temperature $20 \pm 2^{\circ}\text{C}$ and seed treated with cow urine (C_1T_9) had highest seed weight (3.55 g)

4.2 Storage results

After standardization of seed testing procedure for germination, the seed were kept for storage in high density polyethylene bag (HDEP) at room temperature to assess the seed germination and growth of sarpgandha seed. The results are presented below,

4.2.1 Effect of seed treatment on germination (%).

The data regarding effect of seed treatments on germination are presented in Table 18.

From the data, it was revealed that the germination differed significantly due to different seed treatment during all the periods of storage. It was noticed that at 120 days the germination increased up to 50.29 % when the seed was treated with 2% KNO_3 (T_7). There was an increase in germination with the advancement of storage period. The initial germination was 38.75 %. After 120 days the germination was decreased during storage. However the untreated seed i.e. control (T_1) initially showed (18.08 %) after 120 days it showed maximum germination (29.75 %). Germination reduced rapidly after 180 days of storage and reached to 14.37 %.

4.2.2 Effect of germination methods on germination (%).

From the Table 19, it was revealed that the different germination methods had significant effect on germination during all the periods storage. The sand method (M_2) had significantly higher germination than other methods during all the period of storage. The initial germination was (33.54 %) it is increased up to 120 days (45.78 %) and at the end of

storage period it was decreased to 28.61 % in sand method (M₂). The minimum germination was found in cocopeat method. Initially it was (18.82 %) the germination increased up to 120 days of storage and at the end of storage period it was 16.11 %.

4.2.3 Effect of temperature on germination (%)

The data on effect of temperature on germination are presented in the Table 20.

It was evident that temperature had significant effect on germination during all the periods of storage. The $30 \pm 2^{\circ}\text{C}$ temperature (C₃) had significantly higher germination than the other temperatures. At initial stage the germination was 29.51 % however, at 120 days the germination increased up to (41.26 %). At the end of storage period of 180 days the germination was decreased up to 25.04 %.

4.2.4 Interaction effect of germination methods and seed treatment on germination (%)

From the data (Table 21), it was observed that, the interaction of germination method and seed treatment had significant effect on germination during all the periods of storage. Initially the interaction of germination in sand and seed treated with 2% KNO₃ (M₂T₇) showed significantly higher germination (50.83 %), the germination was increased (60.33 %) at 120 days of storage. At the end of storage period (after 180 days) the seed germination was decreased up to 46.67 %.

4.2.5 Interaction effect of temperature and seed treatment on germination (%)

The data on interaction effect of temperature and seed treatments on germination are presented in the Table 22. It was observed that the interactions of temperature and seed treatments had significant effect on germination. Initially the interaction of temperature $30 \pm 2^{\circ}\text{C}$ and seed treated with 2% KNO_3 (C_3T_7) showed significantly higher germination (43.63 %) than the rest of interaction. At 120 days of storage the germination was increased up to 54.75 %. However at the end of storage period of 180 days, the seed germination was decreased up to 38.38 %.

4.2.6 Interaction effect of germination methods and temperature on germination (%)

From the data (Table 23), it was revealed that the interaction of germination method and temperature had significant effect on germination during all the periods of storage. The interaction of germination in sand and kept at $30 \pm 2^{\circ}\text{C}$ for germination (M_2C_3) showed significantly higher germination (40.03 %) than the rest of interactions. After 120 days the germination was increased to 52.54 %. At the end of storage period of 180 days, the seed germination was decreased up to 35.21 %.

4.2.7 Interaction effect of germination methods, temperature and seed treatments on germination (%)

The data regarding effect of interaction between germination methods, temperature and seed treatments on germination are presented in the Table 24.

From the data, it was revealed that the interaction of germination methods, temperature and seed treatments on germination had significant effect during all the periods of storage. The interaction of germination in sand kept at $30 \pm 2^{\circ}\text{C}$ and seed treated with 2% KNO_3 ($\text{M}_2\text{C}_3\text{T}_7$) showed significantly higher germination 57.5% followed by the interaction of germination in sand kept at $30 \pm 2^{\circ}\text{C}$ and seed treated with 1% KNO_3 ($\text{M}_2\text{C}_3\text{T}_6$) 50% at initial stage. The lowest germination (5%) was recorded in the interaction of germination in cocopeat kept at $20 \pm 2^{\circ}\text{C}$ and seed treated with conc. H_2SO_4 for 10 min. ($\text{M}_4\text{C}_1\text{T}_3$).

After 120 days of storage the germination was increased up to 70.00 %. At the end of storage period, the germination i.e. 52.50 % was recorded in interaction ($\text{M}_2\text{C}_3\text{T}_7$).

Table 18 Effect of seed treatment on germination (%)

Treatments	Germination (%)						
	DAS						
	Initial	30	60	90	120	150	180
T1: Control	18.08 (24.70)	19.58 (25.94)	22.87 (22.87)	26.12 (30.48)	29.75 (29.75)	17.58 (24.35)	14.37 (21.60)
T2: conc. H_2SO_4 (3min)	28.58 (31.96)	30.91 (33.52)	33.70 (33.70)	36.20 (36.85)	40.12 (40.12)	28.16 (31.84)	24.33 (29.17)
T3: conc. H_2SO_4 (5min)	20.67 (26.52)	24.25 (29.27)	26.91 (26.91)	29.95 (32.94)	34.00 (34.00)	21.20 (27.08)	17.33 (24.16)
T4: conc. H_2SO_4 (10min)	12.96 (19.79)	14.66 (21.38)	18.00 (18.00)	21.62 (27.38)	25.75 (25.75)	14.00 (21.55)	11.41 (19.26)
T5: 1% KH_2PO_4	25.67 (30.12)	27.45 (31.35)	30.58 (30.58)	34.20 (35.68)	38.50 (38.50)	23.91 (29.04)	21.41 (27.25)
T6: 1% KNO_3	31.92 (34.19)	34.45 (35.78)	38.12 (38.12)	41.54 (40.05)	45.62 (45.62)	31.08 (33.70)	28.07 (31.77)
T7: 2% KNO_3	38.75 (38.41)	41.08 (39.80)	43.45 (43.45)	47.50 (43.56)	50.29 (50.29)	38.25 (38.11)	34.83 (36.06)
T8: 0.5% Thiourea	25.21 (29.95)	27.12 (31.25)	29.41 (29.41)	32.00 (34.35)	35.33 (35.33)	23.95 (29.15)	20.08 (26.16)
T9: Cow urine	21 (26.72)	22.70 (28.07)	25.75 (25.75)	28.66 (32.08)	31.37 (31.37)	19.08 (25.38)	16.83 (23.51)
T10: Mechanical scarification	23.46 (28.07)	24.95 (29.64)	28.66 (28.66)	31.20 (33.68)	34.00 (34.00)	21.25 (27.12)	18.29 (24.76)
T11: Stratification	15.58 (21.81)	18.04 (23.55)	20.79 (20.79)	23.79 (28.49)	26.79 (26.79)	14.58 (21.76)	12.33 (19.19)
T12: Water soaking	20.67 (25.13)	21.25 (25.97)	23.95 (23.95)	27.12 (30.70)	29.29 (29.29)	18.50 (24.86)	15.91 (22.14)
SE $\pm$	0.507	0.166	0.253	0.157	0.374	0.192	0.202
CD @ 5%	1.416	0.463	0.708	0.438	1.045	0.536	0.564

Table 19 Effect of germination methods on germination (%)

Media	Germination (%)						
	DAS						
	Initial	30	60	90	120	150	180
M1: Between paper	20.5 (26.50)	21.47 (27.22)	22.90 (22.90)	24.92 (29.65)	26.92 (26.92)	18.65 (25.10)	17.03 (23.80)
M2: Sand method	33.54 (35.12)	35.42 (36.32)	38.56 (38.56)	41.94 (40.27)	45.78 (45.78)	31.44 (33.80)	28.61 (31.97)
M3: Top of paper	21.32 (27.13)	23.96 (29.03)	27.83 (27.83)	31.60 (34.02)	35.21 (35.21)	20.15 (26.35)	16.66 (23.60)
M4: Cocopeat	18.82 (23.72)	21.32 (25.95)	24.79 (24.79)	28.19 (31.49)	32.38 (32.38)	20.28 (26.08)	16.11 (22.33)
SE $\pm$	0.293	0.096	0.146	0.090	0.216	0.111	0.117
CD @ 5%	0.818	0.267	0.409	0.253	0.603	0.309	0.326

Table 20 Effect of temperature on germination (%)

Temperature	Germination (%)						
	DAS						
	Initial	30	60	90	120	150	180
C1: 20 $\pm$ 2°C	17.53 (23.28)	19.50 (25.07)	22.46 (22.46)	25.29 (29.71)	28.78 (28.78)	17.69 (24.26)	14.21 (21.01)
C2: 25 $\pm$ 2°C	23.59 (28.47)	25.82 (30.06)	28.84 (28.84)	32.01 (34.16)	35.16 (35.16)	22.56 (27.86)	19.56 (25.62)
C3: 30 $\pm$ 2°C	29.51 (32.60)	31.30 (33.75)	34.26 (34.26)	37.69 (37.69)	41.26 (41.26)	27.65 (31.37)	25.04 (29.64)
SE $\pm$	0.253	0.083	0.127	0.078	0.187	0.096	0.101
CD @ 5%	0.708	0.231	0.354	0.219	0.522	0.268	0.282

Table 21 Interaction effect of germination methods and seed treatments on germination (%)

Treatment combination	Germination (%)						
	DAS						
	Initial	30	60	90	120	150	180
M1T1	14 (21.91)	15.00 (22.73)	16.33 (16.33)	18.67 (25.55)	20.67 (20.67)	12.00 (20.18)	10.00 (18.32)
M1T2	29.33 (32.71)	30.33 (33.36)	32.33 (32.33)	34.00 (35.63)	36.33 (36.33)	27.67 (31.67)	25.67 (30.36)
M1T3	22.67 (28.34)	23.67 (29.05)	25.33 (25.33)	27.33 (31.49)	29.33 (29.33)	20.67 (26.97)	19.33 (25.98)
M1T4	12.67 (20.78)	13.67 (21.63)	15.33 (15.33)	17.33 (24.57)	19.67 (19.67)	11.00 (19.26)	9.00 (17.30)
M1T5	26 (30.60)	27.33 (31.46)	29.00 (29.00)	31.00 (33.80)	33.00 (33.00)	24.00 (29.27)	22.33 (28.14)
M1T6	29.33 (32.73)	30.33 (33.38)	31.67 (31.67)	33.67 (35.44)	35.67 (35.67)	27.67 (31.69)	25.67 (30.38)
M1T7	33.33 (35.24)	34.33 (35.85)	34.67 (34.67)	38.33 (38.24)	40.33 (40.33)	31.33 (34.02)	29.33 (32.77)
M1T8	21.67 (27.63)	22.67 (28.35)	24.33 (24.33)	26.33 (30.82)	28.00 (28.00)	20.00 (26.46)	18.67 (25.50)
M1T9	14 (21.93)	15.00 (22.75)	16.33 (16.33)	18.00 (25.09)	19.67 (19.67)	12.00 (20.22)	10.67 (19.03)

Table 21 continued.....

Treatment combination	Germination (%)						
	DAS						
	Initial	30	60	90	120	150	180
M1T10	18 (24.90)	19.00 (25.73)	20.50 (20.50)	22.33 (28.14)	24.33 (24.33)	16.00 (23.43)	14.00 (21.79)
M1T11	10.67 (19.02)	11.33 (19.64)	12.33 (12.33)	14.33 (22.20)	16.33 (16.33)	9.17 (17.52)	7.67 (15.95)
M1T12	14.33 (22.19)	15.00 (22.77)	16.67 (16.67)	17.67 (24.81)	19.67 (19.67)	12.33 (20.52)	12.00 (20.12)
M2T1	28.33 (32.08)	28.33 (32.09)	31.83 (31.83)	35.00 (36.21)	39.17 (39.17)	27.50 (31.51)	24.17 (29.31)
M2T2	39.17 (38.64)	41.67 (40.15)	44.17 (44.17)	46.67 (43.07)	50.83 (50.83)	36.67 (37.17)	34.17 (35.65)
M2T3	27.5 (31.34)	30.83 (33.48)	34.17 (34.17)	38.33 (38.08)	43.33 (43.33)	25.00 (29.68)	21.67 (27.41)
M2T4	20 (26.26)	20.83 (27.03)	25.00 (25.00)	29.17 (32.60)	34.17 (34.17)	17.50 (24.38)	15.83 (23.17)
M2T5	35.83 (36.64)	36.67 (37.12)	40.00 (40.00)	44.17 (41.61)	50.83 (50.83)	32.50 (34.61)	30.00 (33.03)
M2T6	42.5 (40.62)	45.00 (42.09)	50.83 (50.83)	54.17 (47.40)	58.50 (58.50)	40.83 (39.63)	38.33 (38.14)
M2T7	50.83 (45.48)	53.33 (46.92)	56.67 (56.67)	60.83 (51.31)	63.33 (63.33)	50.00 (45.00)	46.67 (43.08)
M2T8	34.17 (35.70)	35.83 (36.75)	37.50 (37.50)	39.17 (38.72)	42.50 (42.50)	32.50 (34.72)	30.00 (33.17)
M2T9	32.5 (34.42)	33.33 (35.15)	35.83 (35.83)	39.17 (38.66)	41.67 (41.67)	30.83 (33.44)	27.50 (31.32)
M2T10	(32.5 (34.61)	34.17 (35.71)	36.67 (36.67)	39.17 (38.67)	42.50 (42.50)	29.00 (32.50)	25.83 (30.22)
M2T11	25.83 (30.46)	29.17 (32.61)	31.67 (31.67)	35.83 (36.70)	38.33 (38.33)	24.17 (29.33)	21.67 (27.59)
M2T12	33.33 (35.21)	35.83 (36.73)	38.33 (38.33)	41.67 (40.17)	44.17 (44.17)	30.83 (33.67)	27.50 (31.58)
M3T1	15 (22.60)	17.50 (24.58)	21.67 (21.67)	25.83 (30.37)	30.00 (30.00)	13.33 (21.28)	10.00 (18.02)
M3T2	24.17 (29.18)	27.50 (31.49)	30.83 (30.83)	34.17 (35.65)	37.50 (37.50)	23.33 (28.78)	20.00 (26.34)
M3T3	18.33 (25.25)	22.50 (28.17)	26.50 (26.50)	30.00 (33.10)	35.00 (35.00)	19.17 (25.88)	15.00 (22.66)
M3T4	11.67 (19.60)	14.17 (21.89)	17.50 (17.50)	21.67 (27.57)	25.83 (25.83)	12.50 (20.63)	9.17 (17.33)
M3T5	20 (26.45)	22.50 (28.22)	25.83 (25.83)	29.17 (32.61)	34.17 (34.17)	17.50 (24.73)	14.17 (22.09)
M3T6	27.5 (31.54)	30.83 (33.65)	35.00 (35.00)	39.17 (38.69)	44.17 (44.17)	27.50 (31.61)	24.13 (29.40)
M3T7	35.83 (36.75)	38.33 (38.24)	41.67 (41.67)	46.67 (43.08)	49.17 (49.17)	37.50 (37.73)	32.50 (34.72)
M3T8	22.5 (28.19)	25.00 (29.92)	27.50 (27.50)	30.83 (33.65)	34.17 (34.17)	21.67 (27.70)	17.50 (24.62)
M3T9	17.5 (24.52)	20.83 (26.99)	25.00 (25.00)	29.17 (32.58)	33.33 (33.33)	15.17 (22.72)	11.67 (19.43)
M3T10	25 (29.81)	25.83 (30.54)	32.50 (32.50)	35.83 (36.72)	39.17 (39.17)	21.67 (27.64)	18.33 (25.18)
M3T11	18.33 (25.25)	22.50 (28.22)	25.83 (25.83)	28.33 (32.13)	31.67 (31.67)	16.67 (24.04)	14.17 (22.05)

Table 21 continued.....

Treatment combination	Germination (%)						
	DAS						
	Initial	30	60	90	120	150	180
M3T12	20 (26.45)	20.00 (26.44)	24.17 (24.17)	28.33 (32.13)	28.33 (28.33)	15.83 (23.39)	13.33 (21.32)
M4T1	15 (22.25)	17.50 (24.38)	21.67 (21.67)	25.00 (29.83)	29.17 (29.17)	17.50 (24.43)	13.33 (20.77)
M4T2	21.67 (27.31)	24.17 (29.12)	27.50 (27.50)	30.00 (33.06)	35.83 (35.83)	25.00 (29.73)	17.50 (24.35)
M4T3	14.17 (21.18)	20.00 (26.38)	21.67 (21.67)	24.17 (29.12)	28.33 (28.33)	20.00 (25.82)	13.33 (20.63)
M4T4	7.5 (12.53)	10.00 (14.99)	14.17 (14.17)	18.33 (24.80)	23.33 (23.33)	15.00 (21.97)	11.67 (19.28)
M4T5	20.83 (26.80)	23.33 (28.62)	27.50 (27.50)	32.50 (34.72)	36.00 (36.00)	21.67 (27.57)	19.17 (25.75)
M4T6	28.33 (31.90)	31.67 (34.03)	35.00 (35.00)	39.17 (38.67)	44.17 (44.17)	28.33 (31.90)	24.17 (29.18)
M4T7	35 (36.20)	38.33 (38.19)	40.83 (40.83)	44.17 (41.61)	48.33 (48.33)	34.17 (35.71)	30.83 (33.67)
M4T8	22.5 (28.28)	25.00 (29.98)	28.33 (28.33)	31.67 (34.22)	36.67 (36.67)	21.67 (27.73)	14.17 (21.38)
M4T9	20 (26.05)	21.67 (27.41)	25.83 (25.83)	28.33 (32.01)	30.83 (30.83)	18.33 (25.14)	17.50 (24.27)
M4T10	18.33 (23.00)	20.83 (26.58)	25.00 (25.00)	27.50 (31.21)	30.00 (30.00)	18.33 (24.92)	15.00 (21.88)
M4T11	7.5 (12.53)	9.17 (13.72)	13.33 (13.33)	16.67 (22.95)	20.83 (20.83)	8.33 (16.16)	5.83 (11.19)
M4T12	15 (16.68)	14.17 (17.97)	16.67 (16.67)	20.83 (25.73)	25.00 (25.00)	15.00 (21.88)	10.83 (15.58)
SE±	1.013	0.331	0.507	0.313	0.747	0.383	0.404
CD @ 5%	2.832	0.926	1.417	0.876	2.089	1.071	1.129

*figures in parentheses indicate arcsine transformed values

Table 22 Interaction effect of temperature and seed treatments on germination (%)

Treatment combination	Germination (%)						
	DAS						
	Initial	30	60	90	120	150	180
C1T1	13 (20.67)	14.50 (22.14)	16.88 (16.88)	19.88 (26.36)	22.88 (22.88)	12.75 (20.68)	9.13 (16.97)
C1T2	20.38 (26.46)	23.13 (28.52)	26.13 (26.13)	28.50 (32.16)	31.50 (31.50)	20.75 (26.95)	17.75 (24.67)
C1T3	14.13 (21.54)	18.13 (25.16)	19.25 (19.25)	21.63 (27.60)	26.50 (26.50)	15.50 (23.02)	11.25 (19.26)
C1T4	7.5 (13.68)	9.00 (15.14)	12.63 (12.63)	15.63 (23.07)	19.25 (19.25)	8.88 (17.09)	7.75 (15.95)
C1T5	18.88 (25.51)	20.38 (26.71)	24.00 (24.00)	28.25 (32.04)	33.75 (33.75)	19.00 (25.77)	16.00 (23.45)
C1T6	24.38 (29.41)	26.50 (30.87)	32.00 (32.00)	35.00 (36.18)	40.50 (40.50)	25.00 (29.88)	21.73 (27.65)
C1T7	33.13 (35.06)	35.25 (36.36)	37.00 (37.00)	41.25 (39.91)	44.88 (44.88)	35.75 (36.60)	31.50 (34.04)
C1T8	21.13 (27.16)	23.25 (28.68)	25.63 (25.63)	28.00 (31.84)	32.25 (32.25)	21.25 (27.32)	14.75 (21.90)
C1T9	14.5 (22.04)	16.63 (23.86)	20.25 (20.25)	23.25 (28.71)	25.63 (25.63)	13.38 (21.26)	10.63 (18.60)

Table 22 continued.....

Treatment combination	Germination (%)						
	DAS						
	Initial	30	60	90	120	150	180
C1T10	16.63 (22.29)	20.00 (26.11)	23.00 (23.00)	24.75 (29.52)	27.75 (27.75)	15.50 (22.93)	11.25 (19.21)
C1T11	11 (16.70)	12.50 (17.86)	15.63 (15.63)	17.38 (23.68)	20.38 (20.38)	11.13 (18.92)	8.38 (14.40)
C1T12	15.75 (18.88)	14.75 (19.49)	17.13 (17.13)	20.00 (25.47)	20.13 (20.13)	13.38 (20.73)	10.38 (16.04)
C2T1	18.25 (24.98)	19.75 (26.16)	23.50 (23.50)	26.75 (30.93)	30.38 (30.38)	18.13 (24.72)	15.13 (22.38)
C2T2	28.5 (32.09)	30.63 (33.46)	33.63 (33.63)	36.00 (36.78)	40.25 (40.25)	29.88 (33.07)	23.75 (28.82)
C2T3	19.88 (26.21)	22.63 (28.29)	26.25 (26.25)	29.88 (33.01)	33.50 (33.50)	18.75 (25.53)	16.63 (23.89)
C2T4	12 (19.76)	14.75 (22.35)	17.75 (17.75)	21.38 (27.35)	25.88 (25.88)	14.25 (22.03)	10.00 (18.12)
C2T5	26 (30.42)	27.50 (31.46)	31.13 (31.13)	34.75 (36.06)	38.38 (38.38)	24.88 (29.69)	22.75 (28.22)
C2T6	33.5 (35.26)	36.25 (36.94)	39.63 (39.63)	42.00 (40.34)	45.00 (45.00)	30.88 (33.64)	27.88 (31.72)
C2T7	39.5 (38.88)	42.25 (40.50)	45.25 (45.25)	48.88 (44.36)	51.25 (51.25)	37.38 (37.62)	34.63 (35.95)
C2T8	26.75 (31.00)	28.88 (32.38)	30.38 (30.38)	34.00 (35.57)	36.38 (36.38)	24.63 (29.60)	21.88 (27.66)
C2T9	20.13 (26.37)	22.25 (27.90)	25.00 (25.00)	27.38 (31.33)	29.75 (29.75)	17.88 (24.72)	15.63 (22.97)
C2T10	23 (28.39)	24.50 (29.48)	27.38 (27.38)	30.25 (33.20)	32.63 (32.63)	20.63 (26.82)	17.63 (24.57)
C2T11	15.88 (22.54)	18.00 (24.05)	21.00 (21.00)	24.63 (29.30)	26.75 (26.75)	14.25 (21.29)	12.38 (19.72)
C2T12	19.75 (25.80)	22.50 (27.81)	25.25 (25.25)	28.25 (31.77)	31.88 (31.88)	19.25 (25.63)	16.50 (23.44)
C3T1	23 (28.48)	24.50 (29.54)	28.25 (28.25)	31.75 (34.18)	36.00 (36.00)	21.88 (27.64)	18.88 (25.46)
C3T2	36.88 (37.33)	39.00 (38.60)	41.38 (41.38)	44.13 (41.61)	48.63 (48.63)	33.88 (35.51)	31.50 (34.04)
C3T3	28 (31.83)	32.00 (34.37)	35.25 (35.25)	38.38 (38.22)	42.00 (42.00)	29.38 (32.71)	24.13 (29.35)
C3T4	19.38 (25.93)	20.25 (26.67)	23.63 (23.63)	27.88 (31.73)	32.13 (32.13)	18.88 (25.55)	16.50 (23.73)
C3T5	32.13 (34.43)	34.50 (35.89)	36.63 (36.63)	39.63 (38.95)	43.38 (43.38)	27.88 (31.67)	25.50 (30.09)
C3T6	37.88 (37.92)	40.63 (39.56)	42.75 (42.75)	47.63 (43.63)	51.38 (51.38)	37.38 (37.60)	34.63 (35.95)
C3T7	43.63 (41.31)	45.75 (42.55)	48.13 (48.13)	52.38 (46.41)	54.75 (54.75)	41.63 (40.13)	38.38 (38.20)
C3T8	27.75 (31.69)	29.25 (32.69)	32.25 (32.25)	34.00 (35.65)	37.38 (37.38)	26.00 (30.54)	23.63 (28.94)
C3T9	28.38 (31.77)	29.25 (32.47)	32.00 (32.00)	35.38 (36.22)	38.75 (38.75)	26.00 (30.16)	24.25 (28.96)
C3T10	30.75 (33.55)	30.38 (33.33)	35.63 (35.63)	38.63 (38.34)	41.63 (41.63)	27.63 (31.62)	26.00 (30.52)
C3T11	19.88 (26.21)	23.63 (28.74)	25.75 (25.75)	29.38 (32.49)	33.25 (33.25)	18.38 (25.08)	16.25 (23.46)
C3T12	26.5 (30.72)	26.50 (30.64)	29.50 (29.50)	33.13 (34.88)	35.88 (35.88)	22.88 (28.24)	20.88 (26.97)
SE $\pm$ CD @ 5%	1.211 3.386	0.399 1.114	0.439 1.227	0.396 1.108	0.647 1.809	0.426 1.192	0.413 1.156

Table 23 Interaction effect of germination methods and temperature on germination (%)

Treatment combination	Germination (%)						
	DAS						
	Initial	30	60	90	120	150	180
M1C1	17.42 (24.28)	18.42 (25.09)	19.83 (19.83)	22.00 (27.70)	24.08 (24.08)	15.75 (22.91)	13.92 (21.37)
M1C2	20 (26.19)	21.00 (26.95)	22.46 (22.46)	24.50 (29.42)	26.50 (26.50)	18.13 (24.76)	16.58 (23.48)
M1C3	24.08 (29.02)	25.00 (29.64)	26.42 (26.42)	28.25 (31.82)	30.17 (30.17)	22.08 (27.63)	20.58 (26.55)
M2C1	25.63 (30.11)	27.71 (31.56)	31.46 (31.46)	33.96 (35.50)	37.50 (37.50)	23.54 (28.69)	20.63 (26.65)
M2C2	35 (36.13)	37.08 (37.40)	39.79 (39.79)	43.75 (41.37)	47.29 (47.29)	32.71 (34.72)	30.00 (33.00)
M2C3	40 (39.13)	41.46 (40.00)	44.42 (44.42)	48.13 (43.92)	52.54 (52.54)	38.08 (38.00)	35.21 (36.26)
M3C1	16.67 (23.72)	19.38 (25.82)	22.92 (22.92)	26.04 (30.49)	28.75 (28.75)	18.54 (25.05)	13.95 (21.29)
M3C2	20.83 (26.88)	23.75 (28.98)	27.92 (27.92)	31.46 (34.03)	35.42 (35.42)	18.79 (25.43)	15.42 (22.73)
M3C3	26.46 (30.80)	28.75 (32.29)	32.67 (32.67)	37.29 (37.56)	41.46 (41.46)	23.13 (28.55)	20.63 (26.77)
M4C1	10.42 (15.03)	12.50 (17.83)	15.63 (15.63)	19.17 (25.17)	24.79 (24.79)	12.92 (20.40)	8.33 (14.74)
M4C2	18.54 (24.70)	21.46 (26.92)	25.21 (25.21)	28.33 (31.85)	31.46 (31.46)	20.63 (26.54)	16.25 (23.27)
M4C3	27.5 (31.44)	30.00 (33.09)	33.54 (33.54)	37.08 (37.46)	40.88 (40.88)	27.29 (31.31)	23.75 (28.97)
SE $\pm$	0.507	0.166	0.253	0.157	0.374	0.192	0.202
CD @ 5%	1.416	0.463	0.708	0.438	1.045	0.536	0.564

*figures in parentheses indicate arcsine transformed values

Table 24 Interaction effect of germination methods, temperature and seed treatments on germination (%)

Treatment combination	Germination (%)						
	DAS						
	Initial	30	60	90	120	150	180
M1C1T1	12 (20.27)	13.00 (21.12)	15.00 (15.00)	17.00 (24.34)	19.00 (19.00)	11.00 (19.35)	9.00 (17.43)
M1C1T2	24 (29.31)	25.00 (30.00)	27.00 (27.00)	29.00 (32.58)	31.00 (31.00)	23.00 (28.65)	21.00 (27.27)
M1C1T3	19 (25.78)	20.00 (26.56)	22.00 (22.00)	24.00 (29.33)	26.00 (26.00)	17.00 (24.34)	15.00 (22.78)
M1C1T4	10 (18.43)	11.00 (19.35)	13.00 (13.00)	15.00 (22.78)	17.00 (17.00)	8.00 (16.40)	6.00 (14.13)
M1C1T5	23 (28.65)	24.00 (29.33)	26.00 (26.00)	28.00 (31.94)	30.00 (30.00)	21.00 (27.27)	19.00 (25.83)
M1C1T6	25 (29.96)	26.00 (30.65)	28.00 (28.00)	30.00 (33.21)	32.00 (32.00)	25.00 (29.96)	22.00 (27.97)
M1C1T7	30 (33.21)	31.00 (33.83)	28.00 (28.00)	35.00 (36.27)	37.00 (37.00)	28.00 (31.94)	26.00 (30.65)

Table 24 continued.....

Treatment combination	Germination (%)						
	DAS						
	Initial	30	60	90	120	150	180
M1C1T8	17 (24.27)	18.00 (25.10)	20.00 (20.00)	22.00 (27.97)	24.00 (24.00)	15.00 (22.78)	14.00 (21.96)
M1C1T9	13 (21.12)	14.00 (21.96)	16.00 (16.00)	18.00 (25.10)	20.00 (20.00)	11.00 (19.35)	10.00 (18.41)
M1C1T10	14 (21.77)	15.00 (22.78)	17.00 (17.00)	19.00 (25.83)	21.00 (21.00)	12.00 (20.25)	10.00 (18.41)
M1C1T11	9 (17.43)	10.00 (18.41)	10.00 (10.00)	12.00 (20.25)	14.00 (14.00)	7.00 (15.30)	6.00 (14.13)
M1C1T12	13 (21.12)	14.00 (21.96)	16.00 (16.00)	15.00 (22.78)	18.00 (18.00)	11.00 (19.35)	9.00 (17.43)
M1C2T1	13 (21.12)	14.00 (21.96)	14.00 (14.00)	17.00 (24.34)	19.00 (19.00)	10.00 (18.41)	8.00 (16.40)
M1C2T2	29 (32.55)	30.00 (33.21)	32.00 (32.00)	34.00 (35.67)	36.00 (36.00)	27.00 (31.30)	25.00 (30.00)
M1C2T3	22 (27.95)	23.00 (28.65)	25.00 (25.00)	27.00 (31.30)	29.00 (29.00)	20.00 (26.56)	19.00 (25.83)
M1C2T4	13 (21.12)	14.00 (21.96)	16.00 (16.00)	18.00 (25.10)	21.00 (21.00)	12.00 (20.25)	10.00 (18.41)
M1C2T5	24 (29.31)	25.00 (30.00)	27.00 (27.00)	29.00 (32.58)	31.00 (31.00)	22.00 (27.97)	21.00 (27.27)
M1C2T6	29 (32.55)	30.00 (33.21)	31.00 (31.00)	33.00 (35.06)	35.00 (35.00)	26.00 (30.65)	24.00 (29.33)
M1C2T7	33 (35.06)	34.00 (35.67)	36.00 (36.00)	38.00 (38.06)	40.00 (40.00)	32.00 (34.45)	31.00 (33.83)
M1C2T8	22 (27.97)	23.00 (28.65)	24.00 (24.00)	26.00 (30.65)	28.00 (28.00)	21.00 (27.27)	20.00 (26.56)
M1C2T9	13 (21.12)	14.00 (21.96)	15.00 (15.00)	17.00 (24.34)	19.00 (19.00)	11.00 (19.35)	10.00 (18.41)
M1C2T10	17 (24.27)	18.00 (25.10)	19.50 (19.50)	21.00 (27.27)	23.00 (23.00)	15.00 (22.78)	13.00 (21.12)
M1C2T11	11 (19.35)	12.00 (20.25)	14.00 (14.00)	16.00 (23.57)	17.00 (17.00)	9.50 (17.90)	7.00 (15.30)
M1C2T12	14 (21.92)	15.00 (22.78)	16.00 (16.00)	18.00 (25.10)	20.00 (20.00)	12.00 (20.25)	11.00 (19.35)
M1C3T1	17 (24.34)	18.00 (25.10)	20.00 (20.00)	22.00 (27.97)	24.00 (24.00)	15.00 (22.78)	13.00 (21.12)
M1C3T2	35 (36.27)	36.00 (36.87)	38.00 (38.00)	39.00 (38.65)	42.00 (42.00)	33.00 (35.06)	31.00 (33.83)
M1C3T3	27 (31.30)	28.00 (31.94)	29.00 (29.00)	31.00 (33.83)	33.00 (33.00)	25.00 (30.00)	24.00 (29.33)
M1C3T4	15 (22.78)	16.00 (23.57)	17.00 (17.00)	19.00 (25.83)	21.00 (21.00)	13.00 (21.12)	11.00 (19.35)
M1C3T5	31 (33.83)	33.00 (35.06)	34.00 (34.00)	36.00 (36.87)	38.00 (38.00)	29.00 (32.58)	27.00 (31.30)
M1C3T6	34 (35.67)	35.00 (36.27)	36.00 (36.00)	38.00 (38.06)	40.00 (40.00)	32.00 (34.45)	31.00 (33.83)
M1C3T7	37 (37.46)	38.00 (38.06)	40.00 (40.00)	42.00 (40.40)	44.00 (44.00)	34.00 (35.67)	31.00 (33.83)
M1C3T8	26 (30.64)	27.00 (31.30)	29.00 (29.00)	31.00 (33.83)	32.00 (32.00)	24.00 (29.33)	22.00 (27.97)
M1C3T9	16 (23.54)	17.00 (24.34)	18.00 (18.00)	19.00 (25.83)	20.00 (20.00)	14.00 (21.96)	12.00 (20.25)
M1C3T10	23 (28.65)	24.00 (29.33)	25.00 (25.00)	27.00 (31.30)	29.00 (29.00)	21.00 (27.27)	19.00 (25.83)
M1C3T11	12 (20.27)	12.00 (20.25)	13.00 (13.00)	15.00 (22.78)	18.00 (18.00)	11.00 (19.35)	10.00 (18.41)

Table 24 continued.....

Treatment combination	Germination (%)						
	DAS						
	Initial	30	60	90	120	150	180
M1C3T12	16 (23.54)	16.00 (23.57)	18.00 (18.00)	20.00 (26.56)	21.00 (21.00)	14.00 (21.96)	16.00 (23.57)
M2C1T1	22.5 (28.28)	22.50 (28.32)	25.00 (25.00)	27.50 (31.63)	30.00 (30.00)	20.00 (26.56)	17.50 (24.73)
M2C1T2	30 (33.14)	32.50 (34.76)	35.00 (35.00)	37.50 (37.76)	40.00 (40.00)	27.50 (31.63)	25.00 (30.00)
M2C1T3	17.5 (24.68)	20.00 (26.56)	22.50 (22.50)	25.00 (30.00)	30.00 (30.00)	15.00 (22.78)	12.50 (20.70)
M2C1T4	12.5 (20.61)	15.00 (22.78)	20.00 (20.00)	22.50 (28.32)	25.00 (25.00)	10.00 (18.41)	10.00 (18.41)
M2C1T5	25 (30.00)	25.00 (30.00)	30.00 (30.00)	35.00 (36.27)	42.50 (42.50)	22.50 (28.32)	20.00 (26.56)
M2C1T6	32.5 (34.74)	35.00 (36.27)	45.00 (45.00)	47.50 (43.57)	52.50 (52.50)	30.00 (33.21)	27.50 (31.63)
M2C1T7	42.5 (40.68)	45.00 (42.13)	50.00 (50.00)	52.50 (46.43)	55.00 (55.00)	45.00 (42.13)	40.00 (39.23)
M2C1T8	30 (33.14)	32.50 (34.76)	35.00 (35.00)	37.50 (37.76)	40.00 (40.00)	27.50 (31.63)	25.00 (30.00)
M2C1T9	22.5 (28.00)	25.00 (30.00)	27.50 (27.50)	30.00 (33.21)	32.50 (32.50)	20.00 (26.56)	17.50 (24.73)
M2C1T10	25 (29.89)	27.50 (31.63)	30.00 (30.00)	30.00 (33.21)	35.00 (35.00)	22.50 (28.32)	15.00 (22.78)
M2C1T11	20 (26.57)	22.50 (28.32)	25.00 (25.00)	27.50 (31.63)	30.00 (30.00)	17.50 (24.73)	15.00 (22.78)
M2C1T12	27.5 (31.61)	30.00 (33.21)	32.50 (32.50)	35.00 (36.27)	37.50 (37.50)	25.00 (30.00)	22.50 (28.32)
M2C2T1	30 (33.21)	30.00 (33.21)	35.00 (35.00)	37.50 (37.76)	42.50 (42.50)	30.00 (33.21)	25.00 (30.00)
M2C2T2	40 (39.23)	42.50 (40.69)	45.00 (45.00)	47.50 (43.57)	52.50 (52.50)	37.50 (37.76)	35.00 (36.27)
M2C2T3	27.5 (31.61)	30.00 (33.21)	35.00 (35.00)	40.00 (39.23)	45.00 (45.00)	25.00 (30.00)	22.50 (28.32)
M2C2T4	20 (26.57)	22.50 (28.32)	25.00 (25.00)	30.00 (33.21)	35.00 (35.00)	17.50 (24.73)	15.00 (22.78)
M2C2T5	40 (39.23)	40.00 (39.23)	42.50 (42.50)	45.00 (42.13)	50.00 (50.00)	37.50 (37.76)	35.00 (36.27)
M2C2T6	45 (42.13)	47.50 (43.57)	52.50 (52.50)	55.00 (47.87)	57.50 (57.50)	42.50 (40.69)	40.00 (39.23)
M2C2T7	52.5 (46.43)	55.00 (47.87)	57.50 (57.50)	62.50 (52.24)	65.00 (65.00)	50.00 (45.00)	47.50 (43.57)
M2C2T8	37.5 (37.75)	40.00 (39.23)	40.00 (40.00)	45.00 (42.13)	47.50 (47.50)	35.00 (36.27)	32.50 (34.76)
M2C2T9	30 (33.14)	32.50 (34.76)	35.00 (35.00)	37.50 (37.76)	40.00 (40.00)	27.50 (31.63)	25.00 (30.00)
M2C2T10	32.5 (34.74)	35.00 (36.27)	37.50 (37.50)	42.50 (40.69)	45.00 (45.00)	30.00 (33.21)	27.50 (31.63)
M2C2T11	30 (33.21)	32.50 (34.76)	35.00 (35.00)	40.00 (39.23)	42.50 (42.50)	27.50 (31.63)	25.00 (30.00)
M2C2T12	35 (36.27)	37.50 (37.76)	37.50 (37.50)	42.50 (40.69)	45.00 (45.00)	32.50 (34.76)	30.00 (33.21)
M2C3T1	32.5 (34.74)	32.50 (34.76)	35.50 (35.50)	40.00 (39.23)	45.00 (45.00)	32.50 (34.76)	30.00 (33.21)
M2C3T2	47.5 (43.57)	50.00 (45.00)	52.50 (52.50)	55.00 (47.87)	60.00 (60.00)	45.00 (42.13)	42.50 (40.69)
M2C3T3	37.5 (37.75)	42.50 (40.69)	45.00 (45.00)	50.00 (45.00)	55.00 (55.00)	35.00 (36.27)	30.00 (33.21)

Table 24 continued.....

Treatment combination	Germination (%)						
	DAS						
	Initial	30	60	90	120	150	180
M2C3T4	27.5 (31.61)	25.00 (30.00)	30.00 (30.00)	35.00 (36.27)	42.50 (42.50)	25.00 (30.00)	22.50 (28.32)
M2C3T5	42.5 (40.68)	45.00 (42.13)	47.50 (47.50)	52.50 (46.43)	60.00 (60.00)	37.50 (37.76)	35.00 (36.27)
M2C3T6	50 (45.00)	52.50 (46.43)	55.00 (55.00)	60.00 (50.77)	65.50 (65.50)	50.00 (45.00)	47.50 (43.57)
M2C3T7	57.5 (49.32)	60.00 (50.77)	62.50 (62.50)	67.50 (55.24)	70.00 (70.00)	55.00 (47.87)	52.50 (46.43)
M2C3T8	35 (36.22)	35.00 (36.27)	37.50 (37.50)	35.00 (36.27)	40.00 (40.00)	35.00 (36.27)	32.50 (34.76)
M2C3T9	45 (42.12)	42.50 (40.69)	45.00 (45.00)	50.00 (45.00)	52.50 (52.50)	45.00 (42.13)	40.00 (39.23)
M2C3T10	40 (39.20)	40.00 (39.23)	42.50 (42.50)	45.00 (42.13)	47.50 (47.50)	34.50 (35.97)	35.00 (36.27)
M2C3T11	27.5 (31.61)	32.50 (34.76)	35.00 (35.00)	40.00 (39.23)	42.50 (42.50)	27.50 (31.63)	25.00 (30.00)
M2C3T12	37.5 (37.75)	40.00 (39.23)	45.00 (45.00)	47.50 (43.57)	50.00 (50.00)	35.00 (36.27)	30.00 (33.21)
M3C1T1	10 (18.43)	12.50 (20.70)	15.00 (15.00)	17.50 (24.73)	20.00 (20.00)	10.00 (18.41)	5.00 (12.86)
M3C1T2	15 (22.79)	20.00 (26.56)	22.50 (22.50)	25.00 (30.00)	27.50 (27.50)	17.50 (24.73)	12.50 (20.70)
M3C1T3	15 (22.79)	17.50 (24.73)	20.00 (20.00)	22.50 (28.32)	27.50 (27.50)	20.00 (26.56)	12.50 (20.70)
M3C1T4	7.5 (15.68)	10.00 (18.41)	12.50 (12.50)	15.00 (22.78)	20.00 (20.00)	12.50 (20.70)	10.00 (18.41)
M3C1T5	15 (22.79)	17.50 (24.73)	20.00 (20.00)	22.50 (28.32)	30.00 (30.00)	17.50 (24.73)	12.50 (20.70)
M3C1T6	22.5 (28.28)	25.00 (30.00)	30.00 (30.00)	32.50 (34.76)	40.00 (40.00)	27.50 (31.63)	22.40 (28.25)
M3C1T7	32.5 (34.74)	35.00 (36.27)	37.50 (37.50)	42.50 (40.69)	45.00 (45.00)	42.50 (40.69)	35.00 (36.27)
M3C1T8	17.5 (24.68)	20.00 (26.56)	22.50 (22.50)	25.00 (30.00)	27.50 (27.50)	20.00 (26.56)	15.00 (22.78)
M3C1T9	12.5 (20.61)	15.00 (22.78)	20.00 (20.00)	25.00 (30.00)	27.50 (27.50)	10.00 (18.41)	5.00 (12.86)
M3C1T10	22.5 (28.28)	27.50 (31.63)	32.50 (32.50)	35.00 (36.27)	37.50 (37.50)	17.50 (24.73)	15.00 (22.78)
M3C1T11	15 (22.79)	17.50 (24.73)	22.50 (22.50)	25.00 (30.00)	27.50 (27.50)	15.00 (22.78)	12.50 (20.70)
M3C1T12	15 (22.79)	15.00 (22.78)	20.00 (20.00)	25.00 (30.00)	15.00 (15.00)	12.50 (20.70)	10.00 (18.41)
M3C2T1	15 (22.79)	17.50 (24.73)	22.50 (22.50)	27.50 (31.63)	32.50 (32.50)	12.50 (20.70)	10.00 (18.41)
M3C2T2	25 (30.00)	27.50 (31.63)	32.50 (32.50)	35.00 (36.27)	40.00 (40.00)	25.00 (30.00)	22.50 (28.32)
M3C2T3	17.5 (24.68)	20.00 (26.56)	25.00 (25.00)	30.00 (33.21)	35.00 (35.00)	15.00 (22.78)	12.50 (20.70)
M3C2T4	10 (18.43)	12.50 (20.70)	17.50 (17.50)	22.50 (28.32)	27.50 (27.50)	10.00 (18.41)	5.00 (12.86)
M3C2T5	20 (26.57)	22.50 (28.32)	27.50 (27.50)	32.50 (34.76)	37.50 (37.50)	17.50 (24.73)	15.00 (22.78)
M3C2T6	27.5 (31.61)	30.00 (33.21)	35.00 (35.00)	37.50 (37.76)	42.50 (42.50)	25.00 (30.00)	22.50 (28.32)
M3C2T7	35 (36.27)	37.50 (37.76)	42.50 (42.50)	47.50 (43.57)	50.00 (50.00)	32.50 (34.76)	27.50 (31.63)

Table 24 continued.....

Treatment combination	Germination (%)						
	DAS						
	Initial	30	60	90	120	150	180
M3C2T8	22.5 (28.28)	25.00 (30.00)	27.50 (27.50)	30.00 (33.21)	32.50 (32.50)	20.00 (26.56)	15.00 (22.78)
M3C2T9	17.5 (24.68)	20.00 (26.56)	22.50 (22.50)	25.00 (30.00)	27.50 (27.50)	15.50 (23.18)	12.50 (20.70)
M3C2T10	22.5 (28.00)	25.00 (30.00)	27.50 (27.50)	30.00 (33.21)	32.50 (32.50)	20.00 (26.56)	15.00 (22.78)
M3C2T11	17.5 (24.68)	22.50 (28.32)	25.00 (25.00)	27.50 (31.63)	30.00 (30.00)	15.00 (22.78)	12.50 (20.70)
M3C2T12	20 (26.57)	25.00 (30.00)	30.00 (30.00)	32.50 (34.76)	37.50 (37.50)	17.50 (24.73)	15.00 (22.78)
M3C3T1	20 (26.57)	22.50 (28.32)	27.50 (27.50)	32.50 (34.76)	37.50 (37.50)	17.50 (24.73)	15.00 (22.78)
M3C3T2	32.5 (34.74)	35.00 (36.27)	37.50 (37.50)	42.50 (40.69)	45.00 (45.00)	27.50 (31.63)	25.00 (30.00)
M3C3T3	22.5 (28.28)	30.00 (33.21)	34.50 (34.50)	37.50 (37.76)	42.50 (42.50)	22.50 (28.32)	20.00 (26.56)
M3C3T4	17.5 (24.68)	20.00 (26.56)	22.50 (22.50)	27.50 (31.63)	30.00 (30.00)	15.00 (22.78)	12.50 (20.70)
M3C3T5	25 (30.00)	27.50 (31.63)	30.00 (30.00)	32.50 (34.76)	35.00 (35.00)	17.50 (24.73)	15.00 (22.78)
M3C3T6	32.5 (34.74)	37.50 (37.76)	40.00 (40.00)	47.50 (43.57)	50.00 (50.00)	30.00 (33.21)	27.50 (31.63)
M3C3T7	40 (39.23)	42.50 (40.69)	45.00 (45.00)	50.00 (45.00)	52.50 (52.50)	37.50 (37.76)	35.00 (36.27)
M3C3T8	27.5 (31.61)	30.00 (33.21)	32.50 (32.50)	37.50 (37.76)	42.50 (42.50)	25.00 (30.00)	22.50 (28.32)
M3C3T9	22.5 (28.28)	27.50 (31.63)	32.50 (32.50)	37.50 (37.76)	45.00 (45.00)	20.00 (26.56)	17.50 (24.73)
M3C3T10	30 (33.14)	25.00 (30.00)	37.50 (37.50)	42.50 (40.69)	47.50 (47.50)	27.50 (31.63)	25.00 (30.00)
M3C3T11	22.5 (28.28)	27.50 (31.63)	30.00 (30.00)	32.50 (34.76)	37.50 (37.50)	20.00 (26.56)	17.50 (24.73)
M3C3T12	25 (30.00)	20.00 (26.56)	22.50 (22.50)	27.50 (31.63)	32.50 (32.50)	17.50 (24.73)	15.00 (22.78)
M4C1T1	7.5 (15.68)	10.00 (18.41)	12.50 (12.50)	17.50 (24.73)	22.50 (22.50)	10.00 (18.41)	5.00 (12.86)
M4C1T2	12.5 (20.61)	15.00 (22.78)	20.00 (20.00)	22.50 (28.32)	27.50 (27.50)	15.00 (22.78)	12.50 (20.70)
M4C1T3	5 (12.92)	15.00 (22.78)	12.51 (12.51)	15.00 (22.78)	22.50 (22.50)	10.00 (18.41)	5.00 (12.86)
M4C1T4	0 (0.00)	0.00 (0.00)	5.00 (5.00)	10.00 (18.41)	15.00 (15.00)	5.00 (12.86)	5.00 (12.86)
M4C1T5	12.5 (20.61)	15.00 (22.78)	20.00 (20.00)	27.50 (31.63)	32.50 (32.50)	15.00 (22.78)	12.50 (20.70)
M4C1T6	17.5 (24.68)	20.00 (26.56)	25.00 (25.00)	30.00 (33.21)	37.50 (37.50)	17.50 (24.73)	15.00 (22.78)
M4C1T7	27.5 (31.61)	30.00 (33.21)	32.50 (32.50)	35.00 (36.27)	42.50 (42.50)	27.50 (31.63)	25.00 (30.00)
M4C1T8	20 (26.57)	22.50 (28.32)	25.00 (25.00)	27.50 (31.63)	37.50 (37.50)	22.50 (28.32)	5.00 (12.86)
M4C1T9	10 (18.43)	12.50 (20.70)	17.50 (17.50)	20.00 (26.56)	22.50 (22.50)	12.50 (20.70)	10.00 (18.41)
M4C1T10	5 (9.22)	10.00 (18.41)	12.50 (12.50)	15.00 (22.78)	17.50 (17.50)	10.00 (18.41)	5.00 (12.86)
M4C1T11	0 (0.00)	0.00 (0.00)	5.00 (5.00)	5.00 (12.86)	10.00 (10.00)	5.00 (12.86)	0.00 (0.00)

Table 24 continued.....

Treatment combination	Germination (%)						
	DAS						
	Initial	30	60	90	120	150	180
M4C1T12	0 (0.00)	0.00 (0.00)	0.00 (0.00)	5.00 (12.86)	10.00 (10.00)	5.00 (12.86)	0.00 (0.00)
M4C2T1	15 (22.79)	17.50 (24.73)	22.50 (22.50)	25.00 (30.00)	27.50 (27.50)	20.00 (26.56)	17.50 (24.73)
M4C2T2	20 (26.57)	22.50 (28.32)	25.00 (25.00)	27.50 (31.63)	32.50 (32.50)	30.00 (33.21)	12.50 (20.70)
M4C2T3	12.5 (20.61)	17.50 (24.73)	20.00 (20.00)	22.50 (28.32)	25.00 (25.00)	15.00 (22.78)	12.50 (20.70)
M4C2T4	5 (12.92)	10.00 (18.41)	12.50 (12.50)	15.00 (22.78)	20.00 (20.00)	17.50 (24.73)	10.00 (18.41)
M4C2T5	20 (26.57)	22.50 (28.32)	27.50 (27.50)	32.50 (34.76)	35.00 (35.00)	22.50 (28.32)	20.00 (26.56)
M4C2T6	32.5 (34.74)	37.50 (37.76)	40.00 (40.00)	42.50 (40.69)	45.00 (45.00)	30.00 (33.21)	25.00 (30.00)
M4C2T7	37.5 (37.75)	42.50 (40.69)	45.00 (45.00)	47.50 (43.57)	50.00 (50.00)	35.00 (36.27)	32.50 (34.76)
M4C2T8	25 (30.00)	27.50 (31.63)	30.00 (30.00)	35.00 (36.27)	37.50 (37.50)	22.50 (28.32)	20.00 (26.56)
M4C2T9	20 (26.57)	22.50 (28.32)	27.50 (27.50)	30.00 (33.21)	32.50 (32.50)	17.50 (24.73)	15.00 (22.78)
M4C2T10	20 (26.57)	20.00 (26.56)	25.00 (25.00)	27.50 (31.63)	30.00 (30.00)	17.50 (24.73)	15.00 (22.78)
M4C2T11	5 (12.92)	5.00 (12.86)	10.00 (10.00)	15.00 (22.78)	17.50 (17.50)	5.00 (12.86)	5.00 (12.86)
M4C2T12	10 (18.43)	12.50 (20.70)	17.50 (17.50)	20.00 (26.56)	25.00 (25.00)	15.00 (22.78)	10.00 (18.41)
M4C3T1	22.5 (28.28)	25.00 (30.00)	30.00 (30.00)	32.50 (34.76)	37.50 (37.50)	22.50 (28.32)	17.50 (24.73)
M4C3T2	32.5 (34.74)	35.00 (36.27)	37.50 (37.50)	40.00 (39.23)	47.50 (47.50)	30.00 (33.21)	27.50 (31.63)
M4C3T3	25 (30.00)	27.50 (31.63)	32.50 (32.50)	35.00 (36.27)	37.50 (37.50)	35.00 (36.27)	22.50 (28.32)
M4C3T4	17.5 (24.68)	20.00 (26.56)	25.00 (25.00)	30.00 (33.21)	35.00 (35.00)	22.50 (28.32)	20.00 (26.56)
M4C3T5	30 (33.21)	32.50 (34.76)	35.00 (35.00)	37.50 (37.76)	40.50 (40.50)	27.50 (31.63)	25.00 (30.00)
M4C3T6	35 (36.27)	37.50 (37.76)	40.00 (40.00)	45.00 (42.13)	50.00 (50.00)	37.50 (37.76)	32.50 (34.76)
M4C3T7	40 (39.23)	42.50 (40.69)	45.00 (45.00)	50.00 (45.00)	52.50 (52.50)	40.00 (39.23)	35.00 (36.27)
M4C3T8	22.5 (28.28)	25.00 (30.00)	30.00 (30.00)	32.50 (34.76)	35.00 (35.00)	20.00 (26.56)	17.50 (24.73)
M4C3T9	30 (33.14)	30.00 (33.21)	32.50 (32.50)	35.00 (36.27)	37.50 (37.50)	25.00 (30.00)	27.50 (31.63)
M4C3T10	30 (33.21)	32.50 (34.76)	37.50 (37.50)	40.00 (39.23)	42.50 (42.50)	27.50 (31.63)	25.00 (30.00)
M4C3T11	17.5 (24.68)	22.50 (28.32)	25.00 (25.00)	30.00 (33.21)	35.00 (35.00)	15.00 (22.78)	12.50 (20.70)
M4C3T12	27.5 (31.61)	30.00 (33.21)	32.50 (32.50)	37.50 (37.76)	40.00 (40.00)	25.00 (30.00)	22.50 (28.32)
SE $\pm$	1.755	0.574	0.878	0.543	1.295	0.664	0.700
CD @ 5%	4.906	1.603	2.454	1.517	3.619	1.855	1.955

*figures in parentheses indicate arcsine transformed values

4.2.8 Effect of seed treatment on root length (cm)

The data regarding effect of seed treatments on root length are presented in Table 25.

From the data, it was revealed that the root length differed significantly due to different seed treatment during all the period of storage. It was also noticed that at 120 days the root length was increased up to 3.26 cm when the seed was treated with 2% KNO₃ (T₇). There was increase in root length with the advancement of storage period. The initial root length was 2.88 cm. After 120 days the root length was decreased during storage. However the untreated seed i.e. control (T₁) at initial stage showed (1.90 cm) root length; after 120 days it showed maximum root length (2.36 cm). Root length reduced rapidly after 180 days of storage and reached to 1.67 cm.

4.2.9 Effect of germination methods on root length (cm)

From the data it was evident that the different germination methods had significant effect on root length during all the period of storage.

The sand method (M₂) had significantly higher root length than other method during all the period of storage. The initial root length was 3.66 cm it which increased up to 120 days (4.24 cm) and at the end of storage period it was decreased to 3.43 cm in sand method (M₂). (Table 26)

4.2.10 Effect of temperatures on root length (cm)

From the data (Table 27), it was revealed that the temperatures used for germination had significant differences in root length. The 30 ± 2°C temperature (C₃) had the higher root length as compared to other temperature treatments. At initial stage the 30 ± 2°C temperature (C₃) showed significantly

higher (2.45 cm) root length among the other temperature treatments. However at 120 days of storage the root length was increase up to (2.79 cm) due to breaking of seed dormancy and increase in germination. At the end of storage period of 180 days the root length was decreased, up to 2.19 cm.

4.2.11 Interaction effect of germination methods and seed treatments on root length (cm)

From the data (Table 28), it was recorded that, the interaction effect of germination method and seed treatment had significant effect on root length during all the periods of storage. Initially the interaction of germination in sand and seed treated with 2% KNO₃ (M₂T₇) showed significantly higher root length (5.24 cm), the root length was increased (5.76 cm) at 120 days of storage. At the end of storage period of (180 days) the root length was decreased up to 4.87 cm.

4.2.12 Interaction effect of temperature and seed treatments on root length (cm)

The data on interaction effect of temperature and seed treatments on root length are presented in the table 29. It was observed that the interactions of temperature and seed treatments had significant effect on root length. Initially the interaction of temperature 30 ± 2°C and seed treated with 2% KNO₃ (C₃T₇) showed significantly higher root length (3.05 cm) after that root length was increased up to 3.42 cm at 120 days of storage. However the end of storage period the root length was decreased up to 2.68 cm.

4.2.13 Interaction effect of germination methods and temperature on root length (cm)

From the data (Table 30), it was revealed that the interaction of germination method and temperature had significant effect on root length during all the periods of storage.

Initially the interaction of germination in sand and kept at $30 \pm 2^{\circ}\text{C}$ for germination (M_2C_3) showed significantly higher root length (4.22 cm) than the rest of interactions at 120 days of storage the root length was increased up to 4.77 cm. The root length was decreases with increases in storage period, however the end of storage period it was 4.00 cm recorded.

4.2.14 Interaction effect of germination methods, temperature and seed treatments on root length (cm)

The data regarding effect of interaction between germination methods, temperature and seed treatments on root length are presented in the Table 31.

From the data, it was revealed that the interaction of germination methods, temperature and seed treatments on root length had significant effect during all the periods of storage. Initially the interaction of germination in sand kept at $30 \pm 2^{\circ}\text{C}$ and seed treated with 2% KNO_3 ($M_2C_3T_7$) showed significantly higher 5.37 cm root length followed by the interaction of germination in sand kept at $30 \pm 2^{\circ}\text{C}$ and seed treated with 1% KNO_3 ($M_2C_3T_6$) 8.46 cm at initial stage. The lowest root length 1.18 cm was recorded in the interaction of germination in cocopeat kept at $20 \pm 2^{\circ}\text{C}$ with untreated seed

i.e. control ($M_4C_1T_1$).

After 120 days of storage the root length was increased up to 5.91 cm. At the end of storage period, the root length (4.98 cm) was recorded in interaction ($M_2C_3T_7$).

Table 25 Main factor effect of seed treatment on root length (cm)

Treatments	Root length (cm)						
	DAS						
	Initial	30	60	90	120	150	180
T1: Control	1.90	2.01	2.05	2.21	2.36	1.82	1.67
T2: conc. H_2SO_4 3 min	2.45	2.47	2.51	2.61	2.77	2.35	2.22
T3: conc. H_2SO_4 5 min	2.31	2.37	2.49	2.50	2.73	2.27	2.07
T4: conc. H_2SO_4 10 min	1.75	1.84	1.98	2.07	2.26	1.73	1.64
T5: 1% KH_2PO_4	2.35	2.34	2.47	2.56	2.73	2.28	2.14
T6: 1% KNO_3	2.64	2.71	2.75	2.90	3.10	2.56	2.42
T7: 2% KNO_3	2.88	2.94	2.98	3.13	3.26	2.74	2.57
T8: 0.5% Thiourea	2.31	2.35	2.39	2.58	2.56	2.20	2.05
T9: Cow urine	1.79	1.84	1.88	1.99	2.14	1.68	1.62
T10: Mechanical scarification	2.05	2.14	2.18	2.30	2.42	1.94	1.83
T11: Stratification	1.59	1.67	1.87	1.92	2.13	1.56	1.42
T12: Water soaking	1.90	1.94	1.97	2.09	2.36	1.93	1.69
SE $\pm$	0.050	0.003	0.009	0.003	0.004	0.003	0.015
CD @ 5%	0.139	0.008	0.024	0.008	0.012	0.008	0.042

Table 26 Main factor effect of germination methods on root length (cm)

Media	Root length (cm)						
	DAS						
	Initial	30	60	90	120	150	180
M1: Between paper	1.78	1.87	1.91	2.03	2.18	1.67	1.53
M2: Sand method	3.66	3.78	3.82	3.98	4.24	3.60	3.43
M3: Top of paper	1.73	1.79	1.86	1.95	2.03	1.64	1.59
M4: Cocopeat	1.49	1.45	1.60	1.67	1.83	1.47	1.25
SE $\pm$	0.003	0.002	0.005	0.002	0.002	0.002	0.009
CD @ 5%	0.008	0.005	0.014	0.005	0.007	0.005	0.024

Table 27 Main factor effect of temperatures on root length (cm)

Temperature	Root length (cm)						
	DAS						
	Initial	30	60	90	120	150	180
C1: $20 \pm 2^\circ C$	1.81	1.92	2.03	2.16	2.35	1.80	1.69
C2: $25 \pm 2^\circ C$	2.23	2.28	2.32	2.43	2.58	2.13	2.01
C3: $30 \pm 2^\circ C$	2.45	2.47	2.55	2.64	2.79	2.34	2.19
SE $\pm$	0.025	0.001	0.004	0.001	0.002	0.001	0.025
CD @ 5%	0.070	0.004	0.012	0.004	0.006	0.004	0.070

Table 28 Interaction effect of germination methods and seed treatments on root length (cm)

Treatment combination	Root length (cm)						
	DAS						
	Initial	30	60	90	120	150	180
M1T1	1.68	1.74	1.78	1.98	2.11	1.57	1.39
M1T2	1.97	2.02	2.04	2.17	2.33	1.89	1.79
M1T3	1.79	1.92	1.96	1.98	2.21	1.72	1.47
M1T4	1.72	1.79	1.83	1.86	2.05	1.66	1.54
M1T5	1.92	2.00	2.04	2.13	2.27	1.82	1.69
M1T6	2.03	2.09	2.13	2.23	2.44	1.93	1.82
M1T7	2.07	2.19	2.23	2.33	2.47	1.94	1.81
M1T8	1.83	1.89	1.93	2.04	2.16	1.75	1.51
M1T9	1.50	1.59	1.63	1.79	1.90	1.42	1.40
M1T10	1.63	1.78	1.82	1.97	2.06	1.46	1.36
M1T11	1.43	1.58	1.62	1.80	1.99	1.23	1.12
M1T12	1.75	1.89	1.93	2.09	2.18	1.63	1.44
M2T1	2.84	3.15	3.20	3.46	3.75	2.84	2.70
M2T2	4.32	4.50	4.54	4.69	4.92	4.30	4.16
M2T3	4.08	4.22	4.26	4.35	4.72	4.06	3.73
M2T4	2.76	2.92	2.96	3.10	3.38	2.49	2.37
M2T5	3.98	4.09	4.13	4.30	4.61	3.92	3.80
M2T6	4.74	4.82	4.86	5.04	5.41	4.67	4.51
M2T7	5.24	5.31	5.34	5.54	5.76	5.09	4.87
M2T8	3.92	4.02	4.05	4.21	4.45	3.91	3.79
M2T9	2.66	2.77	2.82	2.91	3.14	2.60	2.53
M2T10	3.45	3.58	3.62	3.78	3.93	3.47	3.34
M2T11	2.59	2.69	2.73	2.86	3.09	2.56	2.27
M2T12	3.28	3.35	3.39	3.56	3.75	3.25	3.10
M3T1	1.66	1.79	1.83	1.89	1.96	1.56	1.47
M3T2	1.84	1.95	1.98	2.06	2.16	1.78	1.70
M3T3	1.73	1.88	1.92	2.01	2.12	1.66	1.60
M3T4	1.47	1.62	1.66	1.77	1.91	1.37	1.38
M3T5	1.92	1.73	2.10	2.13	2.20	1.84	1.76
M3T6	2.04	2.11	2.14	2.36	2.48	1.96	1.85
M3T7	2.24	2.28	2.32	2.49	2.59	2.10	1.98
M3T8	1.66	1.68	1.73	1.83	1.60	1.54	1.44
M3T9	1.53	1.58	1.62	1.69	1.81	1.41	1.37
M3T10	1.67	1.74	1.78	1.86	1.93	1.53	1.52
M3T11	1.38	1.43	1.47	1.57	1.78	1.28	1.52
M3T12	1.66	1.68	1.71	1.79	1.88	1.59	1.47
M4T1	1.44	1.38	1.42	1.50	1.63	1.33	1.15
M4T2	1.67	1.43	1.47	1.56	1.69	1.46	1.26
M4T3	1.66	1.49	1.85	1.65	1.86	1.64	1.48
M4T4	1.07	1.06	1.51	1.57	1.71	1.42	1.30
M4T5	1.59	1.58	1.62	1.71	1.84	1.56	1.32
M4T6	1.78	1.85	1.89	2.01	2.10	1.71	1.51
M4T7	1.99	1.98	2.02	2.17	2.24	1.85	1.65
M4T8	1.85	1.84	1.88	2.27	2.06	1.63	1.47
M4T9	1.51	1.43	1.47	1.61	1.74	1.30	1.21
M4T10	1.47	1.48	1.52	1.59	1.77	1.31	1.12
M4T11	0.98	1.01	1.69	1.49	1.69	1.19	0.80
M4T12	0.94	0.86	0.89	0.96	1.64	1.27	0.78
SE ±	0.100	0.006	0.017	0.006	0.008	0.006	0.030
CD @ 5%	0.279	0.017	0.048	0.017	0.023	0.017	0.083

Table 29 Interaction effect of temperature and seed treatments on root length (cm)

Treatment combination	Root length (cm)						
	DAS						
	Initial	30	60	90	120	150	180
C1T1	1.70	1.92	1.96	2.15	2.31	1.72	1.50
C1T2	2.04	2.22	2.27	2.39	2.57	1.98	1.88
C1T3	1.83	1.99	2.02	2.13	2.44	1.82	1.56
C1T4	1.32	1.46	1.81	1.88	2.07	1.54	1.47
C1T5	2.00	2.12	2.16	2.24	2.45	1.87	1.75
C1T6	2.41	2.49	2.53	2.64	2.85	2.30	2.18
C1T7	2.72	2.79	2.83	2.95	3.10	2.59	2.34
C1T8	1.87	1.92	1.97	2.38	2.25	1.78	1.69
C1T9	1.54	1.59	1.63	1.81	1.96	1.43	1.44
C1T10	1.74	1.87	1.91	2.01	2.16	1.66	1.56
C1T11	1.19	1.27	1.80	1.74	1.95	1.36	1.27
C1T12	1.39	1.44	1.47	1.58	2.08	1.62	1.18
C2T1	2.00	2.06	2.10	2.23	2.41	1.80	1.69
C2T2	2.61	2.59	2.63	2.73	2.87	2.57	2.42
C2T3	2.45	2.55	2.59	2.64	2.81	2.39	2.25
C2T4	1.89	1.95	1.99	2.07	2.26	1.81	1.71
C2T5	2.36	2.41	2.46	2.55	2.70	2.27	2.14
C2T6	2.67	2.72	2.76	2.97	3.19	2.61	2.48
C2T7	2.89	2.96	3.00	3.14	3.27	2.79	2.71
C2T8	2.38	2.44	2.47	2.52	2.42	2.32	2.11
C2T9	1.86	1.90	1.94	2.03	2.17	1.78	1.67
C2T10	1.96	2.00	2.05	2.17	2.34	1.80	1.75
C2T11	1.74	1.79	1.83	1.97	2.22	1.63	1.52
C2T12	1.96	2.00	2.04	2.16	2.32	1.90	1.75
C3T1	2.01	2.07	2.11	2.25	2.37	1.96	1.85
C3T2	2.70	2.61	2.63	2.74	2.88	2.53	2.40
C3T3	2.66	2.59	2.88	2.73	2.94	2.61	2.41
C3T4	2.06	2.13	2.16	2.29	2.45	1.87	1.77
C3T5	2.71	2.52	2.81	2.91	3.05	2.72	2.55
C3T6	2.86	2.94	2.98	3.12	3.29	2.79	2.62
C3T7	3.05	3.09	3.12	3.31	3.42	2.86	2.68
C3T8	2.70	2.72	2.75	2.87	3.05	2.53	2.37
C3T9	1.99	2.04	2.08	2.16	2.31	1.84	1.78
C3T10	2.47	2.57	2.61	2.73	2.77	2.37	2.21
C3T11	1.85	1.97	2.01	2.08	2.25	1.72	1.50
C3T12	2.37	2.40	2.43	2.56	2.69	2.29	2.16
SE $\pm$	0.086	0.005	0.015	0.005	0.007	0.005	0.026
CD @ 5%	0.241	0.014	0.042	0.015	0.020	0.014	0.072

Table 30 Interaction effect of germination methods and temperature on root length (cm)

Treatment combination	Root length (cm)						
	DAS						
	Initial	30	60	90	120	150	180
M1C1	1.65	1.75	1.80	1.97	2.13	1.60	1.50
M1C2	1.78	1.88	1.92	2.03	2.19	1.67	1.51
M1C3	1.89	1.99	2.02	2.10	2.23	1.74	1.57
M2C1	3.00	3.17	3.21	3.36	3.68	2.88	2.68
M2C2	3.74	3.86	3.90	4.05	4.27	3.73	3.62
M2C3	4.22	4.32	4.36	4.55	4.77	4.18	4.00
M3C1	1.53	1.67	1.71	1.82	1.93	1.44	1.43
M3C2	1.77	1.84	1.88	1.96	1.98	1.66	1.60
M3C3	1.90	1.86	1.98	2.08	2.19	1.81	1.74
M4C1	1.06	1.09	1.39	1.49	1.65	1.30	1.00
M4C2	1.62	1.55	1.59	1.69	1.89	1.49	1.33
M4C3	1.80	1.71	1.83	1.85	1.96	1.64	1.44
SE $\pm$	0.050	0.003	0.009	0.003	0.004	0.003	0.015
CD @ 5%	0.139	0.008	0.024	0.008	0.012	0.008	0.042

Table 31 Interaction effect of germination methods, temperature and seed treatments on root length (cm)

Treatment combination	Root length (cm)						
	DAS						
	Initial	30	60	90	120	150	180
M1C1T1	1.62	1.65	1.69	1.98	2.06	1.84	1.52
M1C1T2	1.86	1.90	1.94	2.06	2.24	1.71	1.69
M1C1T3	1.57	1.67	1.71	1.76	1.98	1.57	1.45
M1C1T4	1.63	1.67	1.71	1.74	2.05	1.64	1.47
M1C1T5	1.82	1.96	2.00	2.00	2.19	1.64	1.48
M1C1T6	1.98	1.98	2.02	2.15	2.48	1.96	1.84
M1C1T7	1.90	2.03	2.07	2.24	2.37	1.84	1.69
M1C1T8	1.57	1.64	1.69	1.89	1.98	1.51	1.42
M1C1T9	1.51	1.66	1.70	1.98	2.06	1.45	1.67
M1C1T10	1.36	1.56	1.60	1.84	1.98	1.24	1.23
M1C1T11	1.51	1.66	1.70	1.95	2.11	1.36	1.24
M1C1T12	1.52	1.67	1.71	1.99	2.05	1.45	1.28
M1C2T1	1.74	1.82	1.86	1.99	2.11	1.36	1.24
M1C2T2	2.00	2.02	2.06	2.21	2.38	1.98	1.84
M1C2T3	1.83	1.96	2.00	2.01	2.24	1.74	1.67
M1C2T4	1.69	1.74	1.78	1.84	1.98	1.58	1.45
M1C2T5	1.93	1.99	2.03	2.24	2.36	1.84	1.76
M1C2T6	2.01	2.13	2.18	2.27	2.42	1.98	1.86
M1C2T7	2.08	2.21	2.24	2.32	2.52	1.99	1.87
M1C2T8	1.91	1.97	2.01	2.01	2.15	1.86	1.45
M1C2T9	1.42	1.49	1.53	1.62	1.76	1.36	1.22

Table 31 continued.....

Treatment combination	Root length (cm)						
	DAS						
	Initial	30	60	90	120	150	180
M1C2T10	1.70	1.82	1.86	1.98	2.08	1.52	1.36
M1C2T11	1.32	1.42	1.46	1.69	1.98	1.10	0.95
M1C2T12	1.80	1.96	2.00	2.15	2.24	1.68	1.49
M1C3T1	1.68	1.74	1.78	1.98	2.15	1.52	1.42
M1C3T2	2.05	2.15	2.13	2.24	2.36	1.98	1.84
M1C3T3	1.97	2.13	2.18	2.18	2.41	1.86	1.28
M1C3T4	1.86	1.96	2.00	2.01	2.12	1.76	1.69
M1C3T5	2.01	2.06	2.10	2.14	2.27	1.98	1.84
M1C3T6	2.10	2.16	2.20	2.27	2.42	1.84	1.76
M1C3T7	2.24	2.34	2.38	2.42	2.52	1.98	1.87
M1C3T8	2.01	2.06	2.10	2.22	2.36	1.87	1.67
M1C3T9	1.58	1.62	1.66	1.76	1.87	1.45	1.32
M1C3T10	1.84	1.96	2.00	2.08	2.12	1.62	1.49
M1C3T11	1.45	1.66	1.70	1.76	1.87	1.23	1.17
M1C3T12	1.94	2.03	2.07	2.12	2.24	1.76	1.54
M2C1T1	2.52	3.12	3.17	3.52	3.86	2.44	2.24
M2C1T2	3.22	3.50	3.54	3.76	4.08	3.15	3.05
M2C1T3	2.96	3.03	3.07	3.22	3.87	2.89	2.14
M2C1T4	2.44	2.66	2.70	2.74	3.05	2.22	2.10
M2C1T5	3.10	3.21	3.25	3.44	3.86	2.98	2.87
M2C1T6	4.23	4.34	4.38	4.52	4.86	4.08	3.86
M2C1T7	4.99	5.04	5.08	5.22	5.52	4.69	4.36
M2C1T8	2.98	3.06	3.10	3.27	3.42	2.86	2.74
M2C1T9	2.15	2.34	2.38	2.45	2.74	2.05	1.98
M2C1T10	2.80	2.90	2.94	3.01	3.21	2.78	2.69
M2C1T11	2.08	2.21	2.25	2.37	2.76	2.00	1.87
M2C1T12	2.59	2.65	2.69	2.76	2.99	2.45	2.21
M2C2T1	3.01	3.21	3.25	3.51	3.86	2.99	2.89
M2C2T2	4.84	4.96	5.00	5.08	5.23	4.78	4.68
M2C2T3	4.52	4.66	4.70	4.76	4.98	4.48	4.37
M2C2T4	2.86	2.96	3.00	3.05	3.22	2.82	2.78
M2C2T5	3.93	4.03	4.08	4.23	4.44	3.89	3.69
M2C2T6	4.87	4.91	4.95	5.24	5.68	4.84	4.69
M2C2T7	5.37	5.47	5.51	5.67	5.86	5.36	5.27
M2C2T8	3.90	4.03	4.07	4.22	4.45	4.01	3.86
M2C2T9	2.89	2.96	3.00	3.05	3.22	2.86	2.76
M2C2T10	2.96	3.12	3.17	3.36	3.52	2.86	2.76
M2C2T11	2.82	2.94	2.98	3.15	3.27	2.84	2.76
M2C2T12	2.97	3.06	3.11	3.24	3.50	3.06	2.95
M2C3T1	3.01	3.13	3.18	3.36	3.52	3.08	2.98
M2C3T2	4.91	5.03	5.08	5.22	5.45	4.98	4.76
M2C3T3	4.76	4.96	5.00	5.08	5.32	4.82	4.69
M2C3T4	2.98	3.13	3.18	3.52	3.86	2.44	2.24
M2C3T5	4.92	5.02	5.07	5.23	5.52	4.89	4.84
M2C3T6	5.12	5.21	5.25	5.36	5.68	5.08	4.99
M2C3T7	5.37	5.42	5.44	5.74	5.91	5.22	4.98
M2C3T8	4.88	4.96	4.99	5.15	5.49	4.86	4.76
M2C3T9	2.93	3.02	3.07	3.22	3.45	2.89	2.86
M2C3T10	4.60	4.72	4.76	4.98	5.05	4.76	4.58

Table 31 continued.....

Treatment combination	Root length (cm)						
	DAS						
	Initial	30	60	90	120	150	180
M2C3T11	2.88	2.91	2.95	3.05	3.23	2.84	2.18
M2C3T12	4.29	4.35	4.37	4.69	4.76	4.24	4.15
M3C1T1	1.49	1.65	1.70	1.76	1.87	1.36	1.28
M3C1T2	1.62	1.85	1.89	1.98	2.12	1.54	1.45
M3C1T3	1.51	1.74	1.78	1.87	1.98	1.45	1.37
M3C1T4	1.21	1.50	1.54	1.69	1.76	1.08	1.13
M3C1T5	1.72	1.96	2.01	2.05	2.08	1.62	1.52
M3C1T6	1.83	1.99	2.03	2.12	2.18	1.76	1.64
M3C1T7	2.08	2.16	2.20	2.35	2.49	1.98	1.84
M3C1T8	1.45	1.49	1.54	1.68	1.76	1.37	1.23
M3C1T9	1.30	1.43	1.47	1.58	1.68	1.23	1.17
M3C1T10	1.51	1.65	1.69	1.76	1.87	1.44	1.36
M3C1T11	1.17	1.21	1.25	1.45	1.65	1.08	1.95
M3C1T12	1.47	1.43	1.47	1.58	1.68	1.36	1.23
M3C2T1	1.71	1.84	1.88	1.93	1.98	1.58	1.45
M3C2T2	1.90	1.96	2.00	2.08	2.12	1.84	1.76
M3C2T3	1.81	1.85	1.89	1.94	2.05	1.76	1.62
M3C2T4	1.48	1.60	1.65	1.76	1.98	1.36	1.36
M3C2T5	1.92	1.97	2.01	1.98	2.08	1.82	1.78
M3C2T6	2.08	2.10	2.14	2.37	2.56	1.94	1.87
M3C2T7	2.27	2.33	2.37	2.49	2.52	2.08	1.98
M3C2T8	1.73	1.82	1.86	1.98	1.08	1.58	1.58
M3C2T9	1.58	1.66	1.70	1.76	1.84	1.45	1.37
M3C2T10	1.72	1.74	1.78	1.84	1.98	1.52	1.68
M3C2T11	1.39	1.43	1.47	1.52	1.68	1.35	1.24
M3C2T12	1.71	1.76	1.78	1.85	1.93	1.68	1.49
M3C3T1	1.79	1.87	1.91	1.98	2.03	1.74	1.68
M3C3T2	2.00	2.04	2.06	2.12	2.24	1.96	1.90
M3C3T3	1.87	2.06	2.09	2.22	2.34	1.78	1.82
M3C3T4	1.72	1.76	1.78	1.87	1.98	1.68	1.65
M3C3T5	2.13	1.25	2.29	2.36	2.45	2.08	1.98
M3C3T6	2.22	2.23	2.26	2.58	2.69	2.18	2.05
M3C3T7	2.38	2.36	2.40	2.62	2.75	2.24	2.12
M3C3T8	1.80	1.74	1.78	1.84	1.96	1.68	1.52
M3C3T9	1.70	1.65	1.69	1.74	1.90	1.54	1.56
M3C3T10	1.78	1.84	1.88	1.98	1.94	1.62	1.52
M3C3T11	1.58	1.66	1.70	1.74	2.01	1.42	1.36
M3C3T12	1.80	1.84	1.88	1.93	2.03	1.74	1.69
M4C1T1	1.18	1.25	1.29	1.35	1.45	1.24	0.95
M4C1T2	1.48	1.65	1.69	1.76	1.84	1.52	1.32
M4C1T3	1.28	1.51	1.50	1.67	1.93	1.36	1.26
M4C1T4	0.00	0.00	1.30	1.34	1.42	1.21	1.18
M4C1T5	1.35	1.33	1.37	1.47	1.67	1.23	1.12
M4C1T6	1.60	1.66	1.70	1.78	1.86	1.41	1.37
M4C1T7	1.91	1.91	1.95	1.99	2.03	1.86	1.48
M4C1T8	1.48	1.49	1.54	2.67	1.82	1.36	1.36
M4C1T9	1.20	0.93	0.97	1.22	1.37	0.98	0.95
M4C1T10	1.31	1.36	1.40	1.42	1.58	1.18	0.95
M4C1T11	0.00	0.00	1.98	1.18	1.28	0.98	0.00

Table 31 continued.....

Treatment combination	Root length (cm)						
	DAS						
	Initial	30	60	90	120	150	180
M4C1T12	0.00	0.00	0.00	0.00	1.58	1.22	0.00
M4C2T1	1.57	1.35	1.39	1.48	1.68	1.26	1.18
M4C2T2	1.72	1.43	1.47	1.56	1.76	1.68	1.38
M4C2T3	1.66	1.74	1.78	1.84	1.98	1.58	1.34
M4C2T4	1.52	1.50	1.54	1.62	1.87	1.47	1.24
M4C2T5	1.65	1.66	1.70	1.76	1.92	1.52	1.32
M4C2T6	1.73	1.74	1.78	1.98	2.08	1.68	1.48
M4C2T7	1.86	1.82	1.86	2.08	2.18	1.72	1.72
M4C2T8	1.98	1.92	1.95	1.86	1.98	1.83	1.54
M4C2T9	1.57	1.50	1.54	1.68	1.86	1.45	1.32
M4C2T10	1.45	1.33	1.37	1.49	1.76	1.28	1.18
M4C2T11	1.45	1.36	1.40	1.52	1.93	1.22	1.12
M4C2T12	1.35	1.22	1.26	1.39	1.62	1.18	1.08
M4C3T1	1.57	1.54	1.58	1.68	1.76	1.48	1.32
M4C3T2	1.82	1.22	1.26	1.36	1.48	1.18	1.08
M4C3T3	2.03	1.22	2.26	1.45	1.68	1.98	1.84
M4C3T4	1.69	1.67	1.70	1.76	1.84	1.58	1.48
M4C3T5	1.78	1.74	1.78	1.89	1.94	1.94	1.52
M4C3T6	2.00	2.16	2.20	2.27	2.36	2.04	1.68
M4C3T7	2.21	2.22	2.26	2.45	2.51	1.98	1.76
M4C3T8	2.10	2.10	2.14	2.27	2.37	1.69	1.52
M4C3T9	1.75	1.85	1.89	1.93	2.00	1.48	1.36
M4C3T10	1.67	1.76	1.80	1.87	1.98	1.48	1.24
M4C3T11	1.49	1.66	1.70	1.76	1.87	1.37	1.28
M4C3T12	1.46	1.36	1.40	1.48	1.72	1.42	1.25
SE $\pm$	0.173	0.010	0.030	0.010	0.014	0.010	0.052
CD @ 5%	0.483	0.029	0.084	0.029	0.040	0.029	0.144

4.2.15 Effect of seed treatment on shoot length (cm)

The data regarding effect of seed treatments on shoot length are presented in Table 32.

From the data, it was revealed that the shoot length differed significantly due to different seed treatment during all the period of storage. It was also noticed that at 120 days the shoot length was increased up to 7.25 cm when the seed was treated with 2% KNO₃ (T₇). There was increase in shoot length with the advancement of storage period. The initial shoot length was 6.94 cm. After 120 days the shoot length was decreased during storage. However the untreated seed i.e.

control (T_1) at initial stage showed (5.05 cm) after 120 days it showed maximum shoot length (5.89 cm). At the end of storage period it was 5.18 cm.

4.2.16 Effect of germination methods on shoot length (cm)

From the data it was evident that the different germination methods had significant effect on shoot length during all the period of storage.

The sand method (M_2) had significantly higher shoot length than other method during all the period of storage. The initial shoot length was 7.77 cm which increased up to 120 days (8.16 cm) and at the end of storage period it was decreased to 7.56 cm in sand method (M_2). (Table 33)

4.2.17 Effect of temperature on shoot length (cm)

The data on effect of temperature on shoot length are presented in the Table 34.

It was evident that temperature had significant effect on shoot length during all the period of storage. At initial stage the $30 \pm 2^\circ\text{C}$ temperature (C_3) showed significantly higher (6.20 cm) shoot length among the other temperature. At 120 days of storage the shoot length was increase up to 6.49 cm due to breaking of seed dormancy. At the end of storage period of (180 days) the shoot length was decreased to 5.96 cm.

4.2.18 Interaction effect of germination methods and seed treatments on shoot length (cm)

From the data (Table 35), it was observed that, the interaction effect of germination method and seed treatment had significant effect on shoot length during all the periods of storage. Initially the interaction of germination in sand and seed treated with 2% KNO_3 (M_2T_7) showed significantly higher

shoot length (8.41 cm), the shoot length was increased (8.77 cm) at 120 days of storage. At the end of storage period of (after 180 days) the shoot length was decreased up to 8.17 cm.

4.2.19 Interaction effect of temperature and seed treatments on shoot length (cm)

The data on interaction effect of temperature and seed treatments on shoot length are presented in the Table 36. It was observed that the interactions of temperature and seed treatments had significant effect on shoot length. Initially the interaction of temperature $30 \pm 2^{\circ}\text{C}$ and seed treated with 2% KNO_3 (C_3T_7) showed significantly higher shoot length (7.30 cm) after that shoot length was increased (7.61 cm) at 120 days of storage. However at the end of storage period the shoot length was decreased up to 6.52 cm. (Table 36)

4.2.20 Interaction effect of germination methods and temperature on shoot length (cm)

From the data (Table 37), it was revealed that the interaction of germination method and temperature had significant effect on shoot length during all the periods of storage. Initially the interaction of germination in sand and kept at $30 \pm 2^{\circ}\text{C}$ for germination (M_2C_3) showed significantly higher shoot length (8.00 cm) than the rest of interactions. After 120 days of storage the shoot length was increased up to (8.29 cm). The shoot length was decreases with increased in storage period, at the end of storage period it was 7.78 cm.

4.2.21 Interaction effect of germination methods, temperature and seed treatments on shoot length (cm)

The data regarding effect of interaction between

germination methods, temperature and seed treatments on shoot length are presented in the Table 38.

From the data, it was revealed that the interaction of germination methods, temperature and seed treatments on shoot length had significant effect during all the periods of storage. Initially the interaction of germination in sand kept at $30 \pm 2^\circ\text{C}$ and seed treated with 2% KNO_3 ($\text{M}_2\text{C}_3\text{T}_7$) showed significantly higher (8.72 cm) shoot length. followed by the interaction of germination in sand kept at $30 \pm 2^\circ\text{C}$ and seed treated with 1% KNO_3 ($\text{M}_2\text{C}_3\text{T}_6$) 8.46 cm. The lowest shoot length (2.11 cm) was recorded in the interaction of germination in cocopeat kept at $20 \pm 2^\circ\text{C}$ and seed treated cow urine ($\text{M}_4\text{C}_1\text{T}_9$).

At 120 days of storage the shoot length was increased up to 9.05 cm. At the end of storage period, the shoot length (8.45 cm) was recorded in interaction ($\text{M}_2\text{C}_3\text{T}_7$).

Table 32 Main factor effect of seed treatment on shoot length (cm)

Treatments	Shoot length (cm)						
	DAS						
	Initial	30	60	90	120	150	180
T1: Control	5.50	5.39	5.63	5.75	5.89	5.27	5.18
T2: conc. H_2SO_4 3 min	6.33	6.05	6.44	6.53	6.44	6.21	6.07
T3: conc. H_2SO_4 5 min	5.98	5.86	6.08	6.11	6.25	5.82	5.72
T4: conc. H_2SO_4 10 min	5.45	4.99	5.57	5.72	5.83	5.30	5.25
T5: 1% KH_2PO_4	6.15	6.05	6.17	6.39	6.55	5.98	5.86
T6: 1% KNO_3	6.53	6.41	6.63	6.66	6.87	6.35	6.27
T7: 2% KNO_3	6.94	6.83	7.05	7.15	7.25	6.63	6.51
T8: 0.5% Thiourea	6.05	5.90	6.12	6.28	6.40	5.91	5.87
T9: Cow urine	5.18	5.08	5.32	5.63	5.77	5.07	4.98
T10: Mechanical scarification	5.63	5.51	5.67	5.91	5.85	5.42	5.34
T11: Stratification	5.08	4.80	5.23	5.52	5.64	4.97	5.05
T12: Water soaking	5.66	5.16	5.43	5.90	6.03	5.46	5.40
SE $\pm$	0.087	0.015	0.034	0.041	0.027	0.038	0.044
CD @ 5%	0.242	0.043	0.095	0.115	0.075	0.106	0.124

Table 33 Effect of germination methods on shoot length (cm)

Media	Shoot length (cm)						
	DAS						
	Initial	30	60	90	120	150	180
M1: Between paper	6.07	5.90	6.18	6.35	6.52	5.89	5.84
M2: Sand method	7.77	7.70	7.89	7.99	8.16	7.64	7.56
M3: Top of paper	5.14	4.98	5.24	5.39	5.44	4.93	4.83
M4: cocopeat	4.52	4.12	4.49	4.80	4.82	4.36	4.28
SE $\pm$	0.050	0.009	0.020	0.024	0.016	0.022	0.026
CD @ 5%	0.140	0.025	0.055	0.066	0.043	0.061	0.072

Table 34 Effect of temperature on shoot length (cm)

Temperature	Shoot length (cm)						
	DAS						
	Initial	30	60	90	120	150	180
C1: 20 $\pm$ 2°C	5.45	5.14	5.47	5.76	5.84	5.32	5.26
C2: 25 $\pm$ 2°C	5.97	5.78	6.11	6.24	6.37	5.78	5.67
C3: 30 $\pm$ 2°C	6.20	6.10	6.26	6.39	6.49	6.01	5.96
SE $\pm$	0.043	0.008	0.017	0.021	0.013	0.019	0.022
CD @ 5%	0.121	0.022	0.047	0.057	0.038	0.053	0.062

Table 35 Interaction effect of germination methods and seed treatments on shoot length (cm)

Treatment combination	Shoot length (cm)						
	DAS						
	Initial	30	60	90	120	150	180
M1T1	5.64	5.50	5.77	5.85	5.97	5.47	5.36
M1T2	6.51	6.04	6.62	6.73	6.88	6.08	5.79
M1T3	6.08	5.94	6.15	6.22	6.34	5.91	5.78
M1T4	5.39	5.28	5.42	5.58	5.66	5.22	5.12
M1T5	6.35	6.25	6.50	6.62	6.79	6.16	6.05
M1T6	6.89	6.72	7.00	7.13	7.30	6.69	6.56
M1T7	7.61	7.48	7.72	7.84	7.89	7.51	7.33
M1T8	6.26	6.00	6.26	6.43	6.58	6.19	6.32
M1T9	5.41	5.28	5.57	6.03	6.52	5.38	5.24
M1T10	5.69	5.56	5.84	5.97	6.07	5.53	5.44
M1T11	5.32	5.19	5.48	5.78	6.11	5.16	5.75
M1T12	5.73	5.58	5.89	5.98	6.09	5.36	5.37
M2T1	7.41	7.30	7.54	7.66	7.83	6.92	6.86
M2T2	8.24	8.48	8.34	8.45	8.46	8.43	8.39
M2T3	7.85	7.74	7.94	8.05	8.20	7.70	7.56
M2T4	7.58	7.46	7.71	7.83	7.94	7.41	7.49
M2T5	7.94	7.91	8.04	8.15	8.36	7.82	7.64
M2T6	8.25	8.14	8.29	8.23	8.62	8.10	8.01
M2T7	8.41	8.32	8.54	8.63	8.77	8.29	8.17
M2T8	7.94	7.87	8.05	8.16	8.32	7.84	7.72
M2T9	7.29	7.22	7.40	7.56	7.69	7.18	7.10
M2T10	7.59	7.48	7.69	7.82	7.94	7.44	7.36
M2T11	7.08	7.00	7.25	7.45	7.67	6.97	7.02
M2T12	7.70	7.47	7.83	7.94	8.09	7.59	7.48
M3T1	4.49	4.41	4.59	4.70	4.88	4.37	4.27

Table 35 continued.....

Treatment combination	Shoot length (cm)						
	DAS						
	Initial	30	60	90	120	150	180
M3T2	5.66	4.91	5.78	5.83	5.24	5.60	5.46
M3T3	5.46	5.37	5.59	5.37	5.50	5.33	5.25
M3T4	4.37	4.26	4.56	4.71	4.86	4.22	4.14
M3T5	5.62	5.51	5.41	5.85	6.02	5.46	5.37
M3T6	5.99	5.87	6.08	6.20	6.36	5.76	5.76
M3T7	6.47	6.42	6.60	6.66	6.83	5.66	5.55
M3T8	5.40	5.25	5.48	5.67	5.76	5.19	5.10
M3T9	4.42	4.29	4.56	4.67	4.80	4.24	4.17
M3T10	4.80	4.70	4.91	5.10	5.21	4.46	4.38
M3T11	4.36	4.25	4.52	5.00	4.80	4.37	4.11
M3T12	4.68	4.57	4.83	4.90	5.04	4.52	4.44
M4T1	4.50	4.38	4.62	4.79	4.91	4.33	4.25
M4T2	4.92	4.80	5.02	5.14	5.22	4.75	4.67
M4T3	4.55	4.40	4.66	4.82	4.98	4.35	4.30
M4T4	4.47	2.99	4.63	4.77	4.90	4.36	4.28
M4T5	4.70	4.56	4.76	4.94	5.03	4.50	4.43
M4T6	5.03	4.93	5.17	5.08	5.20	4.88	4.77
M4T7	5.28	5.13	5.37	5.49	5.53	5.08	5.03
M4T8	4.63	4.48	4.71	4.88	4.96	4.44	4.37
M4T9	3.64	3.56	3.78	4.27	4.07	3.52	3.44
M4T10	4.45	4.33	4.26	4.77	4.20	4.29	4.20
M4T11	3.56	2.80	3.69	3.86	3.99	3.41	3.32
M4T12	4.56	3.05	3.18	4.81	4.93	4.40	4.31
SE $\pm$	0.173	0.031	0.068	0.082	0.054	0.075	0.089
CD @ 5%	0.485	0.087	0.190	0.230	0.151	0.211	0.248

Table 36 Interaction effect of temperature and seed treatments on shoot length (cm)

Treatment combination	Shoot length (cm)						
	DAS						
	Initial	30	60	90	120	150	180
C1T1	5.28	5.18	5.43	5.60	5.78	5.15	5.09
C1T2	5.71	5.81	5.83	5.96	6.06	5.82	5.71
C1T3	5.50	5.40	5.64	5.80	5.94	5.37	5.27
C1T4	5.26	4.11	5.51	5.72	5.84	5.12	5.03
C1T5	5.59	5.49	5.69	5.82	5.98	5.39	5.30
C1T6	6.01	5.91	6.13	6.22	6.38	5.83	5.76
C1T7	6.48	6.39	6.59	6.68	6.75	6.40	6.29
C1T8	5.62	5.37	5.63	5.81	5.98	5.37	5.27
C1T9	4.68	4.59	4.81	5.23	5.16	4.56	4.47
C1T10	5.34	5.22	5.25	5.67	5.30	5.19	5.12
C1T11	4.59	3.99	4.74	4.87	5.10	4.57	4.60
C1T12	5.40	4.22	4.43	5.71	5.86	5.11	5.17
C2T1	5.58	5.45	5.71	5.81	5.95	5.15	5.04
C2T2	6.57	5.73	6.68	6.78	6.95	6.25	6.09
C2T3	6.04	5.91	6.13	5.98	6.15	5.86	5.75
C2T4	5.45	5.34	5.67	5.79	5.91	5.30	5.35
C2T5	6.23	6.09	6.36	6.49	6.65	6.04	5.89

Table 36 continued.....

Treatment combination	Shoot length (cm)						
	DAS						
	Initial	30	60	90	120	150	180
C2T6	6.63	6.46	6.72	6.87	6.82	6.42	6.32
C2T7	7.05	6.95	7.19	7.30	7.40	6.88	6.74
C2T8	6.06	5.93	6.17	6.34	6.43	6.02	5.82
C2T9	5.43	5.33	5.58	5.95	6.34	5.29	5.24
C2T10	5.70	5.59	5.84	6.03	6.10	5.54	5.44
C2T11	5.33	5.22	5.47	5.77	5.78	5.18	5.09
C2T12	5.68	5.43	5.84	5.87	6.01	5.50	5.33
C3T1	5.67	5.55	5.76	5.84	5.97	5.51	5.41
C3T2	6.71	6.64	6.81	6.87	6.34	6.59	6.43
C3T3	6.42	6.29	6.49	6.56	6.67	6.24	6.15
C3T4	5.64	5.54	5.56	5.66	5.76	5.49	5.40
C3T5	6.65	6.60	6.48	6.86	7.02	6.52	6.42
C3T6	6.98	6.87	7.05	6.89	7.41	6.83	6.74
C3T7	7.30	7.17	7.40	7.48	7.61	6.62	6.52
C3T8	6.49	6.40	6.57	6.69	6.80	6.36	6.55
C3T9	5.45	5.35	5.60	5.72	5.81	5.40	5.25
C3T10	5.86	5.75	5.93	6.04	6.17	5.55	5.48
C3T11	5.33	5.22	5.50	5.93	6.05	5.18	5.46
C3T12	5.92	5.85	6.04	6.14	6.24	5.79	5.71
SE $\pm$	0.150	0.027	0.059	0.071	0.047	0.065	0.077
CD @ 5%	0.451	0.075	0.165	0.199	0.130	0.183	0.215

Table 37 Two factor interaction effect of germination methods and temperature on shoot length (cm)

Treatment combination	Shoot length (cm)						
	DAS						
	Initial	30	60	90	120	150	180
M1C1	5.66	5.49	5.78	5.92	6.03	5.45	5.41
M1C2	6.09	5.85	6.23	6.49	6.67	5.86	5.71
M1C3	6.47	6.36	6.54	6.63	6.85	6.35	6.40
M2C1	7.56	7.56	7.70	7.83	8.02	7.53	7.47
M2C2	7.76	7.61	7.89	8.00	8.16	7.52	7.45
M2C3	8.00	7.93	8.07	8.15	8.29	7.87	7.78
M3C1	4.52	4.41	4.67	4.82	4.98	4.39	4.31
M3C2	5.39	5.13	5.51	5.56	5.70	5.26	5.14
M3C3	5.52	5.41	5.54	5.78	5.65	5.14	5.05
M4C1	4.08	3.09	3.73	4.46	4.34	3.92	3.83
M4C2	4.68	4.55	4.82	4.95	4.97	4.50	4.41
M4C3	4.81	4.71	4.91	4.99	5.16	4.66	4.60
SE $\pm$	0.087	0.015	0.034	0.041	0.027	0.038	0.044
CD @ 5%	0.242	0.043	0.095	0.115	0.075	0.106	0.124

Table 38 Interaction effect of germination methods, temperature and seed treatments on shoot length (cm)

Treatment combination	Shoot length (cm)						
	DAS						
	Initial	30	60	90	120	150	180
M1C1T1	5.46	5.31	5.66	5.73	5.86	5.31	5.16
M1C1T2	5.61	5.45	5.79	5.90	6.00	5.64	5.44
M1C1T3	5.62	5.43	5.66	5.79	5.91	5.42	5.30
M1C1T4	5.30	5.22	5.47	5.66	5.78	5.13	5.02
M1C1T5	5.72	5.63	5.88	5.94	6.14	5.42	5.30
M1C1T6	6.17	6.04	6.34	6.46	6.63	5.99	5.93
M1C1T7	7.11	7.08	7.27	7.45	7.18	7.24	6.93
M1C1T8	5.51	4.94	5.27	5.50	5.68	5.07	5.02
M1C1T9	5.30	5.18	5.43	5.62	5.79	5.18	5.11
M1C1T10	5.45	5.26	5.66	5.75	5.91	5.27	5.17
M1C1T11	5.21	5.04	5.34	5.46	5.64	5.03	5.41
M1C1T12	5.43	5.31	5.62	5.74	5.90	4.75	5.17
M1C2T1	5.65	5.47	5.77	5.90	6.04	5.43	5.34
M1C2T2	6.89	5.73	6.94	7.03	7.18	5.71	5.61
M1C2T3	5.83	5.77	5.92	5.94	6.06	5.71	5.61
M1C2T4	5.39	5.27	5.77	5.89	5.94	5.25	5.17
M1C2T5	6.26	6.18	6.43	6.62	6.76	6.16	6.03
M1C2T6	6.87	6.64	6.94	7.12	7.34	6.62	6.44
M1C2T7	7.82	7.58	7.94	8.05	8.30	7.56	7.42
M1C2T8	6.25	6.12	6.46	6.66	6.78	6.60	6.07
M1C2T9	5.44	5.31	5.62	6.73	7.89	5.28	5.30
M1C2T10	5.61	5.47	5.73	5.89	5.94	5.43	5.30
M1C2T11	5.33	5.18	5.44	6.12	5.78	5.15	5.08
M1C2T12	5.70	5.49	5.88	5.94	6.04	5.44	5.12
M1C3T1	5.81	5.71	5.88	5.93	6.02	5.68	5.57
M1C3T2	7.02	6.94	7.12	7.27	7.47	6.90	6.31
M1C3T3	6.78	6.63	6.88	6.92	7.05	6.60	6.43
M1C3T4	5.49	5.34	5.02	5.18	5.27	5.29	5.17
M1C3T5	7.07	6.94	7.18	7.31	7.48	6.91	6.81
M1C3T6	7.64	7.48	7.73	7.82	7.94	7.45	7.30
M1C3T7	7.89	7.78	7.94	8.02	8.20	7.72	7.65
M1C3T8	7.03	6.94	7.07	7.12	7.28	6.91	7.87
M1C3T9	5.48	5.34	5.66	5.75	5.89	5.67	5.30
M1C3T10	6.02	5.94	6.13	6.27	6.37	5.89	5.84
M1C3T11	5.42	5.34	5.66	5.77	6.90	5.30	6.76
M1C3T12	6.05	5.94	6.18	6.26	6.34	5.90	5.84
M2C1T1	7.21	7.12	7.34	7.45	7.70	7.09	7.07
M2C1T2	8.07	8.94	8.18	8.28	8.41	8.91	8.87
M2C1T3	7.70	7.62	7.88	7.94	8.04	7.60	7.44
M2C1T4	7.34	7.18	7.65	7.78	7.89	7.16	7.02
M2C1T5	7.72	7.66	7.82	7.90	8.14	7.63	7.46

Table 38 continued.....

Treatment combination	Shoot length (cm)						
	DAS						
	Initial	30	60	90	120	150	180
M2C1T6	8.10	8.04	8.18	8.27	8.45	8.03	7.93
M2C1T7	8.17	8.11	8.26	8.33	8.50	8.08	8.03
M2C1T8	7.71	7.66	7.88	8.02	8.29	7.62	7.46
M2C1T9	7.13	7.04	7.26	7.40	7.60	7.00	6.91
M2C1T10	7.35	7.22	7.46	7.66	7.80	7.18	7.11
M2C1T11	6.91	6.88	7.09	7.27	7.63	6.84	7.22
M2C1T12	7.34	7.26	7.44	7.63	7.84	7.21	7.07
M2C2T1	7.42	7.36	7.66	7.77	7.91	6.30	6.17
M2C2T2	8.26	8.18	8.39	8.46	8.70	8.14	8.02
M2C2T3	7.80	7.66	7.92	8.03	8.20	7.62	7.43
M2C2T4	7.58	7.44	7.66	7.78	7.89	7.40	7.85
M2C2T5	7.91	7.77	8.04	8.12	8.29	7.73	7.42
M2C2T6	8.18	8.04	8.27	8.40	8.64	7.99	7.92
M2C2T7	8.35	8.19	8.47	8.61	8.75	8.16	8.02
M2C2T8	7.93	7.88	8.02	8.11	8.25	7.84	7.76
M2C2T9	7.31	7.27	7.44	7.62	7.72	7.23	7.17
M2C2T10	7.55	7.44	7.66	7.78	7.89	7.41	7.33
M2C2T11	7.10	6.94	7.22	7.43	7.63	6.91	6.81
M2C2T12	7.70	7.12	7.88	7.93	8.03	7.54	7.46
M2C3T1	7.59	7.43	7.63	7.77	7.88	7.38	7.33
M2C3T2	8.40	8.31	8.45	8.61	8.27	8.25	8.27
M2C3T3	8.06	7.94	8.03	8.18	8.36	7.89	7.81
M2C3T4	7.82	7.76	7.82	7.93	8.04	7.69	7.61
M2C3T5	8.21	8.30	8.27	8.43	8.65	8.10	8.03
M2C3T6	8.46	8.34	8.43	8.02	8.78	8.30	8.17
M2C3T7	8.72	8.66	8.88	8.94	9.05	8.62	8.45
M2C3T8	8.17	8.08	8.26	8.34	8.42	8.06	7.93
M2C3T9	7.44	7.36	7.51	7.66	7.77	7.31	7.21
M2C3T10	7.87	7.77	7.94	8.03	8.13	7.73	7.65
M2C3T11	7.25	7.18	7.44	7.66	7.75	7.16	7.02
M2C3T12	8.07	8.04	8.18	8.27	8.41	8.02	7.91
M3C1T1	4.18	4.12	4.27	4.50	4.67	4.09	4.07
M3C1T2	4.48	4.40	4.58	4.77	4.89	4.34	4.26
M3C1T3	4.32	4.27	4.50	4.71	4.89	4.23	4.17
M3C1T4	4.10	4.04	4.45	4.70	4.83	3.99	3.93
M3C1T5	4.42	4.33	4.62	4.73	4.89	4.27	4.17
M3C1T6	5.02	4.94	5.12	5.23	5.40	4.71	4.87
M3C1T7	5.76	5.65	5.88	5.93	6.15	5.61	5.57
M3C1T8	4.89	4.62	4.94	5.07	5.17	4.56	4.48
M3C1T9	4.18	4.04	4.27	4.47	4.62	4.00	3.93
M3C1T10	4.31	4.22	4.46	4.63	4.75	4.18	4.11
M3C1T11	4.15	4.05	4.34	4.48	4.68	4.51	3.91
M3C1T12	4.43	4.31	4.66	4.70	4.82	4.27	4.26
M3C2T1	4.58	4.47	4.66	4.69	4.89	4.43	4.30

Table 38 continued.....

Treatment combination	Shoot length (cm)						
	DAS						
	Initial	30	60	90	120	150	180
M3C2T2	6.21	4.12	6.36	6.50	6.67	6.29	6.02
M3C2T3	5.89	5.77	5.94	5.08	5.25	5.73	5.65
M3C2T4	4.43	4.33	4.59	4.73	4.89	4.31	4.17
M3C2T5	6.06	5.94	6.18	6.31	6.47	5.89	5.81
M3C2T6	6.38	6.22	6.46	6.62	6.83	6.17	6.11
M3C2T7	6.72	6.80	6.88	6.91	7.09	6.61	6.43
M3C2T8	5.37	5.27	5.47	5.72	5.76	5.22	5.07
M3C2T9	4.50	4.40	4.66	4.71	4.88	4.35	4.26
M3C2T10	5.22	5.12	5.34	5.65	5.65	5.07	5.02
M3C2T11	4.60	4.52	4.77	4.89	4.95	4.47	4.39
M3C2T12	4.76	4.66	4.88	4.91	5.10	4.61	4.45
M3C3T1	4.72	4.63	4.85	4.91	5.09	4.58	4.43
M3C3T2	6.28	6.22	6.40	6.22	4.15	6.17	6.11
M3C3T3	6.18	6.08	6.34	6.31	6.37	6.03	5.93
M3C3T4	4.58	4.43	4.63	4.71	4.86	4.38	4.33
M3C3T5	6.37	6.27	5.43	6.51	6.72	6.22	6.12
M3C3T6	6.56	6.45	6.66	6.76	6.86	6.40	6.30
M3C3T7	6.95	6.83	7.03	7.13	7.27	4.77	4.65
M3C3T8	5.93	5.85	6.03	6.22	6.35	5.80	5.76
M3C3T9	4.57	4.43	4.76	4.85	4.90	4.38	4.33
M3C3T10	4.89	4.77	4.94	5.03	5.25	4.12	4.02
M3C3T11	4.35	4.18	4.46	5.63	4.79	4.13	4.03
M3C3T12	4.84	4.73	4.94	5.08	5.20	4.68	4.61
M4C1T1	4.29	4.18	4.43	4.71	4.88	4.13	4.07
M4C1T2	4.68	4.43	4.76	4.90	4.94	4.38	4.26
M4C1T3	4.35	4.27	4.50	4.76	4.92	4.22	4.17
M4C1T4	0.00	0.00	4.47	4.73	4.88	4.22	4.13
M4C1T5	4.49	4.34	4.43	4.72	4.77	4.24	4.26
M4C1T6	4.74	4.62	4.88	4.94	5.05	4.58	4.33
M4C1T7	4.89	4.73	4.94	5.02	5.17	4.68	4.65
M4C1T8	4.36	4.27	4.44	4.66	4.77	4.22	4.11
M4C1T9	2.11	2.08	2.26	3.44	2.63	2.06	1.93
M4C1T10	4.27	4.17	3.43	4.64	2.74	4.13	4.07
M4C1T11	0.00	0.00	2.18	2.28	2.47	1.91	0.00
M4C1T12	0.00	0.00	0.00	4.78	4.90	4.22	0.00
M4C2T1	4.66	4.52	4.76	4.89	4.95	4.47	4.36
M4C2T2	4.93	4.88	5.04	5.12	5.25	4.84	4.72
M4C2T3	4.64	4.43	4.74	4.88	5.09	4.38	4.30
M4C2T4	4.42	4.31	4.66	4.76	4.94	4.26	4.22
M4C2T5	4.67	4.45	4.81	4.93	5.07	4.40	4.30
M4C2T6	5.08	4.94	5.22	5.34	4.47	4.89	4.80
M4C2T7	5.32	5.23	5.45	5.62	5.48	5.17	5.11
M4C2T8	4.69	4.46	4.76	4.89	4.94	4.42	4.36
M4C2T9	4.49	4.34	4.61	4.76	4.88	4.29	4.21

Table 38 continued.....

Treatment combination	Shoot length (cm)						
	DAS						
	Initial	30	60	90	120	150	180
M4C2T10	4.42	4.31	4.62	4.82	4.95	4.26	4.11
M4C2T11	4.30	4.23	4.47	4.63	4.75	4.18	4.07
M4C2T12	4.56	4.46	4.70	4.71	4.88	4.42	4.30
M4C3T1	4.56	4.43	4.66	4.77	4.89	4.38	4.33
M4C3T2	5.16	5.08	5.27	5.40	5.47	5.03	5.02
M4C3T3	4.67	4.51	4.73	4.83	4.92	4.46	4.42
M4C3T4	4.69	4.65	4.77	4.81	4.87	4.60	4.49
M4C3T5	4.95	4.88	5.04	5.18	5.25	4.85	4.72
M4C3T6	5.28	5.22	5.40	4.97	6.08	5.17	5.17
M4C3T7	5.63	5.43	5.73	5.84	5.93	5.38	5.32
M4C3T8	4.85	4.73	4.94	5.08	5.17	4.68	4.65
M4C3T9	4.32	4.27	4.46	4.62	4.70	4.22	4.17
M4C3T10	4.66	4.52	4.72	4.84	4.93	4.47	4.42
M4C3T11	4.30	4.18	4.43	4.66	4.75	4.13	4.03
M4C3T12	4.72	4.68	4.84	4.94	5.01	4.57	4.46
SE $\pm$	0.300	0.054	0.118	0.142	0.093	0.131	0.154
CD @ 5%	0.873	0.150	0.329	0.398	0.261	0.365	0.430

4.2.22 Effect of seed treatment on seedling dry weight (mg)

The data regarding effect of seed treatments on seedling dry weight are presented in Table 39.

From the data, it was revealed that the seedling dry weight differed significantly due to different seed treatment during all the periods of storage. It was also noticed that at 120 days the seedling dry weight increased up to 251.67 mg when the seed was treated with 2% KNO₃ (T₇). There was an increase in seedling dry weight with the advancement of storage period. The initial seedling dry weight was 238.33 mg. After 120 days seedling dry weight was decreased during storage. However the untreated control initially showed (167.08 mg) after 120 days it showed maximum seedling dry weight (180.00 mg). Seedling dry weight reduced rapidly after 180 days of storage, and reached to 158.75 mg.

4.2.23 Effect of germination methods on seedling dry weight (mg)

From the data, it was revealed that the different germination methods had significant effect on seedling dry weight presented in Table 40.

The sand method (M_2) had significantly higher seedling dry weight than other method during all the period of storage. The initial seedling dry weight was (207.36 mg) it is increased up to 120 days (215.14 mg) and at the end of storage period it was decreased to 195.17 mg in sand method (M_2).

4.2.24 Effect of temperature on seedling dry weight (mg)

The data on effect of temperature on seedling dry weight are presented in the Table 41.

It was evident that temperature had significant effect on seedling dry weight during all the period of storage. The $30 \pm 2^\circ\text{C}$ temperature (C_3) had significantly higher seedling dry weight than the other temperature. At initial stage the seedling dry weight was 197.81 mg however at 120 days of storage the seedling dry weight was increased up to (209.47 mg). At the end of storage period (180 days) the seedling dry weight was decreased to 188.13 mg.

4.2.25 Interaction effect of germination methods and seed treatments on seedling dry weight (mg)

From the data (Table 42), it was observed that, the interaction effect of germination method and seed treatment had significant effect on seedling dry weight during all the periods of storage. Initially the interaction of germination in sand and seed treated with 2% KNO_3 (M_2T_7) showed

significantly higher seedling dry weight (266.67 mg), the seedling dry weight was increased (278.33 mg) at 120 days of storage. At the end of storage period (180 days) the seedling dry weight was decreased up to 258.67 mg.

4.2.26 Interaction effect of temperature and seed treatments on seedling dry weight (mg)

The data on interaction effect of temperature and seed treatments on seedling dry weight are presented in the Table 43. It was observed that the interactions of temperature and seed treatments had significant effect on seedling dry weight. Initially the interaction of temperature $30 \pm 2^{\circ}\text{C}$ and seed treated with 2% KNO_3 (C_3T_7) showed significantly higher seedling dry weight (256.25 mg) at 120 days of storage the seedling dry weight was increased up to 270.00 mg. However the end of storage period of 180 days, the seed seedling dry weight was decreased up to 248.75 mg.

4.2.27 Interaction effect of germination methods and temperature on seedling dry weight (mg)

From the data, it was revealed that the interaction of germination method and temperature had significant effect on seedling dry weight during all the periods of storage presented in Table 44.

The interaction of germination in sand and kept at $30 \pm 2^{\circ}\text{C}$ for germination (M_2C_3) showed significantly higher seedling dry weight (226.25 mg) than the rest of interactions. After 120 days the seedling dry weight was increased up to 237.50 mg. At the end of storage period seedling dry weight was lowered, up to 217.08 mg.

4.2.28 Interaction effect of germination methods, temperature and seed treatments on seedling dry weight (mg)

The data regarding effect of interaction between germination methods, temperature and seed treatments on seedling dry weight are presented in the Table 45.

From the data, it was revealed that the interaction of germination methods, temperature and seed treatments on seedling dry weight had significant effect during all the periods of storage. The interaction of germination in sand kept at $30 \pm 2^{\circ}\text{C}$ and seed treated with 2% KNO_3 ($\text{M}_2\text{C}_3\text{T}_7$) showed significantly higher seedling dry weight 285.00 mg. at initial stage, followed by the interaction of germination in sand kept at $30 \pm 2^{\circ}\text{C}$ and seed treated with 1% KNO_3 ($\text{M}_2\text{C}_3\text{T}_6$) 265.00 mg. The lowest seedling dry weight (55.00 mg) was recorded in the interaction of germination in cocopeat kept at $20 \pm 2^{\circ}\text{C}$ and seed treated cow urine ($\text{M}_4\text{C}_1\text{T}_9$).

After 120 days of storage the seedling dry weight was increased 300.00 mg. At the end of storage period, the seedling dry weight (285.00 mg) was recorded in interaction ($\text{M}_2\text{C}_3\text{T}_7$).

Table 39 Effect of seed treatment on seedling dry weight (mg)

Treatments	Seedling dry weight (mg)						
	DAS						
	Initial	30	60	90	120	150	180
T1: Control	167.08	162.08	170.83	175.00	180.00	162.92	158.75
T2: conc.H ₂ SO ₄ 3min	194.17	189.00	198.33	202.08	206.25	190.42	185.83
T3: conc. H ₂ SO ₄ 5min	172.50	168.00	180.83	181.25	185.42	167.50	162.92
T4: conc. H ₂ SO ₄ 10min	161.25	138.75	167.50	172.08	176.29	156.25	151.67
T5: 1% KH ₂ PO ₄	196.67	191.67	200.83	205.83	205.83	191.67	187.08
T6: 1% KNO ₃	221.67	216.67	225.96	230.83	235.00	216.71	212.50
T7: 2% KNO ₃	238.33	233.33	242.50	248.33	251.67	230.00	228.42
T8: 0.5% Thiourea	178.75	172.17	185.00	185.83	206.67	171.67	167.08
T9: Cow urine	147.92	152.33	169.58	160.00	164.13	143.75	139.17
T10: Mechanical scarification	167.50	161.92	171.25	176.25	180.33	162.08	157.50
T11: Stratification	141.67	140.42	146.67	151.25	154.58	141.25	132.50
T12: Water soaking	172.50	150.17	157.50	172.92	177.08	160.42	155.42
SE ±	4.79	0.29	1.73	0.29	1.21	1.76	0.29
CD@5%	13.38	0.80	4.83	0.81	3.39	4.92	0.81

Table 40 Effect of germination methods on seedling dry weight (mg)

Media	Seedling dry weight (mg)						
	DAS						
	Initial	30	60	90	120	150	180
M1: Between paper	194.17	186.11	196.39	201.39	209.15	190.00	185.14
M2: Sand method	207.36	202.44	212.50	213.47	215.14	200.29	195.17
M3: Top of paper	167.50	162.69	171.53	176.67	180.25	161.94	157.22
M4: cocopeat	150.97	140.92	158.51	162.36	169.88	145.97	142.08
SE ±	2.764	0.165	0.998	0.167	0.700	1.015	0.167
CD @ 5%	7.726	0.461	2.790	0.466	1.957	2.838	0.466

Table 41 Effect of temperature on seedling dry weight (mg)

Temperature	Seedling dry weight (mg)						
	DAS						
	Initial	30	60	90	120	150	180
C1: 20 ± 2°C	153.75	142.48	153.75	162.60	171.88	148.85	145.02
C2: 25 ± 2°C	188.43	181.33	194.71	196.87	199.46	182.71	176.56
C3: 30 ± 2°C	197.81	195.31	205.73	205.94	209.47	192.08	188.13
SE ±	2.394	0.143	0.864	0.144	0.606	0.879	0.144
CD @ 5%	6.691	0.399	2.416	0.403	1.695	2.458	0.403

Table 42 Interaction effect of germination methods and seed treatments on seedling dry weight (mg)

Treatment combination	Seedling dry weight (mg)						
	c						
	Initial	30	60	90	120	150	180
M1T1	186.67	181.67	190.00	195.00	200.00	185.00	181.67
M1T2	205.00	198.33	208.33	213.33	218.33	205.00	200.00
M1T3	193.33	188.33	196.67	201.67	206.67	188.33	183.33
M1T4	171.67	133.33	175.00	180.00	185.00	166.67	161.67
M1T5	205.00	200.00	206.67	211.67	216.67	200.00	193.33
M1T6	216.67	211.67	218.33	223.33	228.33	211.67	208.33
M1T7	240.00	235.00	241.67	246.67	251.67	218.33	230.00
M1T8	196.67	190.00	196.67	201.67	240.00	190.00	185.00
M1T9	171.67	170.00	176.67	181.67	186.50	170.00	165.00
M1T10	190.00	181.67	190.00	195.00	200.00	183.33	178.33
M1T11	161.67	156.67	163.33	168.33	173.33	175.00	153.33
M1T12	191.67	186.67	193.33	198.33	203.33	186.67	181.67
M2T1	176.67	171.67	181.67	181.67	186.67	171.67	166.67
M2T2	231.67	226.67	236.67	236.67	238.33	226.67	221.67
M2T3	203.33	198.33	208.33	211.67	213.33	198.33	193.33
M2T4	193.33	188.33	198.33	201.67	203.33	188.33	183.33
M2T5	221.67	216.67	226.67	231.67	233.33	216.67	211.67
M2T6	248.33	243.33	253.33	258.33	260.00	243.50	238.33
M2T7	266.67	261.67	271.67	276.67	278.33	265.00	258.67
M2T8	226.67	221.67	231.67	236.67	238.33	221.67	216.67
M2T9	165.00	193.33	203.33	175.00	176.67	160.00	155.00
M2T10	196.67	191.67	201.67	206.67	208.33	191.67	186.67
M2T11	155.00	150.00	161.67	165.00	163.33	150.00	145.00
M2T12	203.33	166.00	175.00	180.00	181.67	170.00	165.00
M3T1	148.33	143.33	150.00	156.67	161.67	143.33	138.33
M3T2	181.67	177.67	185.00	190.00	195.00	176.67	171.67
M3T3	161.67	158.67	181.67	170.00	175.00	156.67	151.67
M3T4	131.67	126.67	136.67	141.67	146.67	126.67	121.67
M3T5	180.00	175.00	185.00	190.00	178.33	175.00	171.67
M3T6	211.67	206.67	216.67	221.67	226.67	206.67	201.67
M3T7	250.00	245.00	255.00	260.00	265.00	245.00	240.00
M3T8	165.00	155.33	146.67	168.33	173.33	153.33	148.33
M3T9	136.67	132.67	141.67	146.67	151.67	131.67	126.67
M3T10	156.67	152.67	161.67	166.67	171.33	151.67	146.67
M3T11	136.67	131.67	143.33	148.33	153.33	131.67	128.33
M3T12	150.00	147.00	155.00	160.00	165.00	145.00	140.00
M4T1	156.67	151.67	161.67	166.67	171.67	151.67	148.33
M4T2	158.33	153.33	163.33	168.33	173.33	153.33	150.00
M4T3	131.67	126.67	136.67	141.67	146.67	126.67	123.33
M4T4	148.33	106.67	160.00	165.00	170.17	143.33	140.00
M4T5	180.00	175.00	185.00	190.00	195.00	175.00	171.67
M4T6	210.00	205.00	215.50	220.00	225.00	205.00	201.67
M4T7	196.67	191.67	201.67	210.00	211.67	191.67	185.00
M4T8	126.67	121.67	165.00	136.67	175.00	121.67	118.33
M4T9	118.33	113.33	156.67	136.67	141.67	113.33	110.00
M4T10	126.67	121.67	131.67	136.67	141.67	121.67	118.33
M4T11	113.33	123.33	118.33	123.33	128.33	108.33	103.33
M4T12	145.00	101.00	106.67	153.33	158.33	140.00	135.00
SE $\pm$	9.574	0.571	3.457	0.577	2.426	3.517	0.577
CD @ 5%	26.763	1.597	9.664	1.614	6.780	9.831	1.614

Table 43 Interaction effect of temperature and seed treatments on seedling dry weight (mg)

Treatment combination	Seedling dry weight (mg)						
	DAS						
	Initial	30	60	90	120	150	180
C1T1	141.25	136.25	145.00	147.50	152.50	138.75	136.25
C1T2	171.25	165.00	176.25	181.25	186.25	170.00	166.25
C1T3	147.50	143.25	152.50	157.50	162.50	142.50	138.75
C1T4	137.50	105.00	142.50	147.50	152.50	132.50	128.75
C1T5	175.00	170.00	178.75	183.75	188.75	170.00	166.25
C1T6	196.25	191.25	200.00	205.00	210.00	191.25	188.75
C1T7	212.50	207.50	216.25	221.25	226.25	207.50	201.50
C1T8	145.00	135.00	131.25	148.75	203.75	135.00	131.25
C1T9	115.00	110.75	118.75	128.75	135.00	110.00	106.25
C1T10	143.75	138.75	147.50	152.50	157.50	138.75	135.00
C1T11	108.75	90.00	113.75	118.75	123.75	103.75	100.00
C1T12	151.25	117.00	122.50	158.75	163.75	146.25	141.25
C2T1	173.75	168.75	178.75	183.75	188.75	168.75	163.75
C2T2	202.50	198.25	207.50	212.50	215.00	197.50	192.50
C2T3	182.50	177.50	200.00	192.50	195.00	177.50	172.50
C2T4	166.25	136.25	176.25	181.25	183.88	161.25	156.25
C2T5	197.50	192.50	202.50	207.50	210.00	192.50	187.50
C2T6	225.00	220.00	230.38	235.00	237.50	220.13	215.00
C2T7	246.25	241.25	251.25	258.75	258.75	241.25	235.00
C2T8	188.75	184.50	193.75	198.75	201.25	183.75	178.75
C2T9	155.00	150.00	185.00	166.25	167.50	150.00	145.00
C2T10	177.50	170.75	180.00	185.00	187.25	171.25	166.25
C2T11	151.25	171.25	156.25	161.25	163.75	160.00	142.50
C2T12	195.00	165.00	175.00	180.00	185.00	168.75	163.75
C3T1	186.25	181.25	188.75	193.75	198.75	181.25	176.25
C3T2	208.75	203.75	211.25	212.50	217.50	203.75	198.75
C3T3	187.50	183.25	190.00	193.75	198.75	182.50	177.50
C3T4	180.00	175.00	183.75	187.50	192.50	175.00	170.00
C3T5	217.50	212.50	221.25	226.25	218.75	212.50	207.50
C3T6	243.75	238.75	247.50	252.50	257.50	238.75	233.75
C3T7	256.25	251.25	260.00	265.00	270.00	241.25	248.75
C3T8	202.50	197.00	230.00	210.00	215.00	196.25	191.25
C3T9	173.75	196.25	205.00	185.00	189.88	171.25	166.25
C3T10	181.25	176.25	186.25	191.25	196.25	176.25	171.25
C3T11	165.00	160.00	170.00	173.75	176.25	160.00	155.00
C3T12	171.25	168.50	175.00	180.00	182.50	166.25	161.25
SE $\pm$	8.292	0.495	2.994	0.500	2.101	3.046	0.500
CD @ 5%	23.876	1.383	8.369	1.398	5.872	8.514	1.398

Table 44 Interaction effect of germination methods and temperature on seedling dry weight (mg)

Treatment combination	Seedling dry weight (mg)						
	DAS						
	Initial	30	60	90	120	150	180
M1C1	185.83	180.42	187.50	192.50	205.83	182.92	178.33
M1C2	193.75	179.58	197.92	202.92	207.92	192.92	183.75
M1C3	202.92	198.33	203.75	208.75	213.71	194.17	193.33
M2C1	180.00	175.00	185.00	188.75	193.75	175.00	170.08
M2C2	215.83	202.50	220.83	217.50	214.17	203.79	198.33
M2C3	226.25	229.83	231.67	234.17	237.50	222.08	217.08
M3C1	135.83	129.92	135.00	144.58	149.58	129.17	125.00
M3C2	180.42	176.17	189.58	190.42	195.33	175.42	170.42
M3C3	186.25	182.00	190.00	195.00	195.83	181.25	176.25
M4C1	113.33	84.58	107.50	124.58	138.33	108.33	106.67
M4C2	163.75	167.08	170.54	176.67	180.46	158.75	153.75
M4C3	175.83	171.08	197.50	185.83	190.83	170.83	165.83
SE $\pm$	4.787	0.286	1.729	0.289	1.213	1.758	0.289
CD @ 5%	13.381	0.798	4.832	0.807	3.390	4.915	0.807

Table 45 Interaction effect of germination methods, temperature and seed treatments on seedling dry weight (mg)

Treatment combination	Seedling dry weight (mg)						
	DAS						
	Initial	30	60	90	120	150	180
M1C1T1	180.00	175.00	185.00	190.00	195.00	185.00	185.00
M1C1T2	195.00	185.00	200.00	205.00	210.00	205.00	200.00
M1C1T3	185.00	180.00	190.00	195.00	200.00	180.00	175.00
M1C1T4	160.00	155.00	165.00	170.00	175.00	155.00	150.00
M1C1T5	210.00	205.00	210.00	215.00	220.00	205.00	195.00
M1C1T6	205.00	200.00	205.00	210.00	215.00	200.00	200.00
M1C1T7	230.00	225.00	230.00	235.00	240.00	225.00	220.00
M1C1T8	190.00	185.00	190.00	195.00	300.00	185.00	180.00
M1C1T9	160.00	155.00	160.00	165.00	170.00	155.00	150.00
M1C1T10	180.00	175.00	180.00	185.00	190.00	175.00	170.00
M1C1T11	150.00	145.00	150.00	155.00	160.00	145.00	140.00
M1C1T12	185.00	180.00	185.00	190.00	195.00	180.00	175.00
M1C2T1	185.00	180.00	190.00	195.00	200.00	180.00	175.00
M1C2T2	210.00	205.00	215.00	220.00	225.00	205.00	200.00
M1C2T3	200.00	195.00	205.00	210.00	215.00	195.00	190.00
M1C2T4	170.00	65.00	175.00	180.00	185.00	165.00	160.00
M1C2T5	195.00	190.00	200.00	205.00	210.00	190.00	185.00
M1C2T6	215.00	210.00	220.00	225.00	230.00	210.00	205.00
M1C2T7	240.00	235.00	245.00	250.00	255.00	235.00	230.00
M1C2T8	190.00	185.00	195.00	200.00	205.00	185.00	180.00

Table 45 continued.....

Treatment combination	Seedling dry weight (mg)						
	DAS						
	Initial	30	60	90	120	150	180
M1C2T9	170.00	165.00	175.00	180.00	185.00	165.00	160.00
M1C2T10	190.00	175.00	185.00	190.00	195.00	180.00	175.00
M1C2T11	165.00	160.00	170.00	175.00	180.00	215.00	160.00
M1C2T12	195.00	190.00	200.00	205.00	210.00	190.00	185.00
M1C3T1	195.00	190.00	195.00	200.00	205.00	190.00	185.00
M1C3T2	210.00	205.00	210.00	215.00	220.00	205.00	200.00
M1C3T3	195.00	190.00	195.00	200.00	205.00	190.00	185.00
M1C3T4	185.00	180.00	185.00	190.00	195.00	180.00	175.00
M1C3T5	210.00	205.00	210.00	215.00	220.00	205.00	200.00
M1C3T6	230.00	225.00	230.00	235.00	240.00	225.00	220.00
M1C3T7	250.00	245.00	250.00	255.00	260.00	195.00	240.00
M1C3T8	210.00	200.00	205.00	210.00	215.00	200.00	195.00
M1C3T9	185.00	190.00	195.00	200.00	204.50	190.00	185.00
M1C3T10	200.00	195.00	205.00	210.00	215.00	195.00	190.00
M1C3T11	170.00	165.00	170.00	175.00	180.00	165.00	160.00
M1C3T12	195.00	190.00	195.00	200.00	205.00	190.00	185.00
M2C1T1	135.00	130.00	140.00	130.00	135.00	130.00	125.00
M2C1T2	210.00	205.00	215.00	220.00	225.00	205.00	200.00
M2C1T3	175.00	170.00	180.00	185.00	190.00	170.00	165.00
M2C1T4	165.00	160.00	170.00	175.00	180.00	160.00	155.00
M2C1T5	200.00	195.00	205.00	210.00	215.00	195.00	190.00
M2C1T6	230.00	225.00	235.00	240.00	245.00	225.00	220.00
M2C1T7	250.00	245.00	255.00	260.00	265.00	245.00	241.00
M2C1T8	200.00	195.00	205.00	210.00	215.00	195.00	190.00
M2C1T9	135.00	130.00	140.00	145.00	150.00	130.00	125.00
M2C1T10	170.00	165.00	175.00	180.00	185.00	165.00	160.00
M2C1T11	125.00	120.00	130.00	135.00	140.00	120.00	115.00
M2C1T12	165.00	160.00	170.00	175.00	180.00	160.00	155.00
MCT2T1	185.00	180.00	190.00	195.00	200.00	180.00	175.00
M2C2T2	235.00	230.00	240.00	245.00	240.00	230.00	225.00
M2C2T3	210.00	205.00	215.00	220.00	215.00	205.00	200.00
M2C2T4	200.00	195.00	205.00	210.00	205.00	195.00	190.00
M2C2T5	225.00	220.00	230.00	235.00	230.00	220.00	215.00
M2C2T6	250.00	245.00	255.00	260.00	255.00	245.50	240.00
M2C2T7	265.00	260.00	270.00	275.00	270.00	260.00	250.00
M2C2T8	230.00	225.00	235.00	240.00	235.00	225.00	220.00
M2C2T9	175.00	170.00	280.00	185.00	180.00	170.00	165.00
M2C2T10	205.00	200.00	210.00	215.00	210.00	200.00	195.00
M2C2T11	165.00	160.00	170.00	175.00	170.00	160.00	155.00
M2C2T12	245.00	140.00	150.00	155.00	160.00	155.00	150.00
M2C3T1	210.00	205.00	215.00	220.00	225.00	205.00	200.00
M2C3T2	250.00	245.00	255.00	245.00	250.00	245.00	240.00
M2C3T3	225.00	220.00	230.00	230.00	235.00	220.00	215.00
M2C3T4	215.00	210.00	220.00	220.00	225.00	210.00	205.00
M2C3T5	240.00	235.00	245.00	250.00	255.00	235.00	230.00
M2C3T6	265.00	260.00	270.00	275.00	280.00	260.00	255.00
M2C3T7	285.00	280.00	290.00	295.00	300.00	290.00	285.00
M2C3T8	250.00	245.00	255.00	260.00	265.00	245.00	240.00

Table 45 continued.....

Treatment combination	Seedling dry weight (mg)						
	DAS						
	Initial	30	60	90	120	150	180
M2C3T9	185.00	280.00	190.00	195.00	200.00	180.00	175.00
M2C3T10	215.00	210.00	220.00	225.00	230.00	210.00	205.00
M2C3T11	175.00	170.00	185.00	185.00	180.00	170.00	165.00
M2C3T12	200.00	198.00	205.00	210.00	205.00	195.00	190.00
M3C1T1	120.00	115.00	120.00	130.00	135.00	115.00	110.00
M3C1T2	150.00	145.00	155.00	160.00	165.00	145.00	140.00
M3C1T3	130.00	128.00	135.00	140.00	145.00	125.00	120.00
M3C1T4	110.00	105.00	115.00	120.00	125.00	105.00	100.00
M3C1T5	150.00	145.00	155.00	160.00	165.00	145.00	145.00
M3C1T6	175.00	170.00	180.00	185.00	190.00	170.00	165.00
M3C1T7	205.00	200.00	210.00	215.00	220.00	200.00	195.00
M3C1T8	125.00	100.00	60.00	115.00	120.00	100.00	95.00
M3C1T9	110.00	108.00	115.00	120.00	125.00	105.00	100.00
M3C1T10	125.00	120.00	130.00	135.00	140.00	120.00	115.00
M3C1T11	100.00	95.00	110.00	115.00	120.00	95.00	95.00
M3C1T12	130.00	128.00	135.00	140.00	145.00	125.00	120.00
M3C2T1	165.00	160.00	170.00	175.00	180.00	160.00	155.00
M3C2T2	200.00	198.00	205.00	210.00	215.00	195.00	190.00
M3C2T3	175.00	170.00	230.00	185.00	190.00	170.00	165.00
M3C2T4	135.00	130.00	140.00	145.00	150.00	130.00	125.00
M3C2T5	185.00	180.00	190.00	195.00	200.00	180.00	175.00
M3C2T6	215.00	210.00	220.00	225.00	230.00	210.00	205.00
M3C2T7	270.00	265.00	275.00	280.00	285.00	265.00	260.00
M3C2T8	180.00	178.00	185.00	190.00	195.00	175.00	170.00
M3C2T9	135.00	130.00	140.00	145.00	150.00	130.00	125.00
M3C2T10	180.00	178.00	185.00	190.00	194.00	175.00	170.00
M3C2T11	145.00	140.00	150.00	155.00	160.00	140.00	135.00
M3C2T12	180.00	175.00	185.00	190.00	195.00	175.00	170.00
M3C3T1	160.00	155.00	160.00	165.00	170.00	155.00	150.00
M3C3T2	195.00	190.00	195.00	200.00	205.00	190.00	185.00
M3C3T3	180.00	178.00	180.00	185.00	190.00	175.00	170.00
M3C3T4	150.00	145.00	155.00	160.00	165.00	145.00	140.00
M3C3T5	205.00	200.00	210.00	215.00	170.00	200.00	195.00
M3C3T6	245.00	240.00	250.00	255.00	260.00	240.00	235.00
M3C3T7	275.00	270.00	280.00	285.00	290.00	270.00	265.00
M3C3T8	190.00	188.00	195.00	200.00	205.00	185.00	180.00
M3C3T9	165.00	160.00	170.00	175.00	180.00	160.00	155.00
M3C3T10	165.00	160.00	170.00	175.00	180.00	160.00	155.00
M3C3T11	165.00	160.00	170.00	175.00	180.00	160.00	155.00
M3C3T12	140.00	138.00	145.00	150.00	155.00	135.00	130.00
M4C1T1	130.00	125.00	135.00	140.00	145.00	125.00	125.00
M4C1T2	130.00	125.00	135.00	140.00	145.00	125.00	125.00
M4C1T3	100.00	95.00	105.00	110.00	115.00	95.00	95.00
M4C1T4	0.00	0.00	120.00	125.00	130.00	110.00	110.00
M4C1T5	140.00	135.00	145.00	150.00	155.00	135.00	135.00
M4C1T6	175.00	170.00	180.00	185.00	190.00	170.00	170.00
M4C1T7	165.00	160.00	170.00	175.00	180.00	160.00	150.00
M4C1T8	65.00	60.00	70.00	75.00	180.00	60.00	60.00

Table 45 continued.....

Treatment combination	Seedling dry weight (mg)						
	DAS						
	Initial	30	60	90	120	150	180
M4C1T9	55.00	50.00	60.00	85.00	95.00	50.00	50.00
M4C1T10	100.00	95.00	105.00	110.00	115.00	95.00	95.00
M4C1T11	0.00	0.00	65.00	70.00	75.00	55.00	0.00
M4C1T12	0.00	0.00	0.00	130.00	135.00	120.00	0.00
M4C2T1	160.00	155.00	165.00	170.00	175.00	155.00	150.00
M4C2T2	165.00	160.00	170.00	175.00	180.00	160.00	155.00
M4C2T3	145.00	140.00	150.00	155.00	160.00	140.00	135.00
M4C2T4	160.00	155.00	185.00	190.00	195.50	155.00	150.00
M4C2T5	185.00	180.00	190.00	195.00	200.00	180.00	175.00
M4C2T6	220.00	215.00	226.50	230.00	235.00	215.00	210.00
M4C2T7	210.00	205.00	215.00	230.00	225.00	205.00	200.00
M4C2T8	155.00	150.00	160.00	165.00	170.00	150.00	145.00
M4C2T9	140.00	135.00	145.00	155.00	155.00	135.00	130.00
M4C2T10	135.00	130.00	140.00	145.00	150.00	130.00	125.00
M4C2T11	130.00	225.00	135.00	140.00	145.00	125.00	120.00
M4C2T12	160.00	155.00	165.00	170.00	175.00	155.00	150.00
M4C3T1	180.00	175.00	185.00	190.00	195.00	175.00	170.00
M4C3T2	180.00	175.00	185.00	190.00	195.00	175.00	170.00
M4C3T3	150.00	145.00	155.00	160.00	165.00	145.00	140.00
M4C3T4	170.00	165.00	175.00	180.00	185.00	165.00	160.00
M4C3T5	215.00	210.00	220.00	225.00	230.00	210.00	205.00
M4C3T6	235.00	230.00	240.00	245.00	250.00	230.00	225.00
M4C3T7	215.00	210.00	220.00	225.00	230.00	210.00	205.00
M4C3T8	160.00	155.00	265.00	170.00	175.00	155.00	150.00
M4C3T9	160.00	155.00	265.00	170.00	175.00	155.00	150.00
M4C3T10	145.00	140.00	150.00	155.00	160.00	140.00	135.00
M4C3T12	150.00	145.00	155.00	160.00	165.00	145.00	140.00
M4C3T12	150.00	148.00	155.00	160.00	165.00	145.00	140.00
SE $\pm$	16.583	0.990	5.988	1.000	4.201	6.091	1.000
CD @ 5%	47.749	2.766	16.738	2.795	11.743	17.027	2.795

4.2.29 Effect of seed treatment on vigour index-I

The data regarding effect of seed treatments on vigour index-I are presented in Table 46.

From the data, it was revealed that the vigour index-I differed significantly due to different seed treatment during all the periods of storage. It was noticed that the vigour index-I increased when seed treated with 2% KNO₃ (T₇) with the advancement of storage period. Initially the vigour index-I was (383.92) at 120 days of storage the seed treated with 2% KNO₃ showed maximum (526.94) vigour index-I. The vigour index-I

was decreased with increased in storage period, at the end of storage period it was 319.11.

4.2.30 Effect of germination methods on vigour index-I

From the data, it was revealed that the different germination methods had significant effect on vigour index-I during all the period storage.

The sand method (M₂) had significantly higher vigour index-I than other during all the period of storage. The initial vigour index-I was (325.70) it was increased up to 120 days (477.76) and at the end of storage period it was decreased to (265.46) in sand method (M₂). (Table 47)

4.2.31 Effect of temperature on vigour index-I

The data on effect of temperature on germination are presented in the Table 48.

It was evident that temperature had significant effect on vigour index-I during all the period of storage. The $30 \pm 2^{\circ}\text{C}$ temperature (C₃) had significantly higher vigour index-I among the different temperature. At initial stage (264.25) vigour index-I was recorded, after 120 days of storage the vigour index-I was increased up to (385.85). At the end of storage period the vigour index-I was decreased to 211.71.

4.2.32 Interaction effect of germination methods and seed treatments on vigour index-I

From the data (Table 49), it was observed that, the interaction effect of germination method and seed treatment had significant effect on vigour index-I during all the period of storage. Initially the interaction of germination in sand and seed treated with 2% KNO₃ (M₂T₇) showed significantly higher

vigour index-I (535.52), the vigour index-I was increased (713.43) at 120 days of storage. At the end of storage period of (180 days) the seed vigour index-I was decreased to 466.73.

4.2.33 Interaction effect of temperature and seed treatments on vigour index-I

The data on interaction effect of temperature and seed treatments on vigour index-I are presented in the Table 50, it was observed that the interactions of temperature and seed treatments had significant effect on vigour index-I. Initially the interaction of temperature $30 \pm 2^{\circ}\text{C}$ and seed treated with 2% KNO_3 (C_3T_7) showed significantly higher vigour index-I (452.03) after that vigour index-I was increased (599.89) at 120 days of storage. However the end of storage period of 180 days, the vigour index-I was decreased, to 354.54.

4.2.34 Interaction effect of germination methods and temperature on vigour index-I

From the data (Table 51), it was revealed that the interaction of germination method and temperature had significant effect on vigour index-I during all the periods of storage. The interaction of germination in sand and kept at $30 \pm 2^{\circ}\text{C}$ for germination (M_2C_3) showed significantly higher vigour index-I (400.20) than the rest of interactions. After 120 days the vigour index-I was increased to 556.30. At the end of storage period Vigour index-I was lowered, up to 332.87.

4.2.35 Interaction effect of germination methods, temperature and seed treatments on vigour index-I

The data regarding effect of interaction between germination methods, temperature and seed treatments on vigour index-I are presented in the Table 52.

From the data it was revealed that the interaction of germination methods, temperature and seed treatments had significant effect on vigour index-I during all the periods of storage. The interaction of germination in sand kept at $30 \pm 2^{\circ}\text{C}$ and seed treated with 2% KNO_3 ($\text{M}_2\text{C}_3\text{T}_7$) showed significantly higher vigour index-I 630.58 followed by the interaction of germination in sand kept at $30 \pm 2^{\circ}\text{C}$ and seed treated with 1% KNO_3 ($\text{M}_2\text{C}_3\text{T}_6$) 528.00. The lowest vigour index-I 22.50 was recorded in the interaction of germination in cocopeat kept at $20 \pm 2^{\circ}\text{C}$ and seed treated cow urine ($\text{M}_4\text{C}_1\text{T}_9$).

After 120 days of storage the vigour index-I was increased up to 809.98. At the end of storage period, the vigour index-I (541.80) was recorded in interaction ($\text{M}_2\text{C}_3\text{T}_7$).

Table 46 Effect of seed treatment on vigour index-I

Treatment	Vigour index-I						
	DAS						
	Initial	30	60	90	120	150	180
T1: Control	140.50	149.68	179.40	210.57	247.19	128.17	106.11
T2: conc. H_2SO_4 3 min	264.34	276.62	312.39	341.46	376.92	250.83	214.80
T3: conc. H_2SO_4 5 min	181.95	207.51	239.10	265.38	311.46	176.30	142.54
T4: conc. H_2SO_4 10min	101.97	113.14	141.65	173.26	212.59	101.24	82.64
T5: 1% KH_2PO_4	229.34	240.98	272.87	313.24	363.60	205.82	180.14
T6: 1% KNO_3	300.84	320.52	362.35	399.57	455.61	282.61	251.27
T7: 2% KNO_3	383.92	403.23	436.17	488.22	526.94	358.99	319.11
T8: 0.5% Thiourea	217.27	229.38	254.84	285.96	317.78	199.84	168.43
T9: Cow urine	154.02	164.18	190.32	221.40	249.30	135.86	117.84
T10: Mechanical scarification	186.68	196.52	229.06	258.14	285.44	160.52	136.05
T11: Stratification	113.58	130.49	154.06	186.38	214.74	101.33	87.21
T12: Water soaking	163.08	170.48	198.25	227.18	253.42	144.66	122.98
SE $\pm$	6.789	2.320	2.811	2.719	3.438	2.594	2.350
CD @ 5%	18.977	6.485	7.858	7.601	9.611	7.251	6.570

Table 47 Effect of germination methods on vigour index-I

Media	Vigour index-I						
	DAS						
	Initial	30	60	90	120	150	180
M1: Between paper	212.88	220.80	241.95	270.25	302.05	190.02	170.31
M2: sand method	325.70	344.08	382.71	424.78	477.76	297.35	265.46
M3: Top of paper	153.56	168.75	203.90	238.79	269.67	137.16	111.83
M4: cocopeat	120.38	133.97	161.61	189.76	222.20	124.22	95.44
SE $\pm$	3.919	1.339	1.623	1.569	1.985	1.498	1.357
CD @ 5%	10.956	3.744	4.537	4.388	5.549	4.186	3.793

Table 48 Effect of temperature on vigour index-I

Temperature	Vigour index-I						
	DAS						
	Initial	30	60	90	120	150	180
C1: 20 $\pm$ 2°C	139.85	155.47	181.82	211.271	245.82	135.56	109.97
C2: 25 $\pm$ 2°C	205.27	218.58	252.34	286.194	322.09	187.75	160.59
C3: 30 $\pm$ 2°C	264.25	276.64	308.46	345.23	385.85	238.24	211.71
SE $\pm$	3.394	1.160	1.406	1.359	1.719	1.297	1.175
CD @ 5%	9.488	3.242	3.929	3.800	4.805	3.626	3.285

Table 49 Interaction effect of germination methods and seed treatments on vigour index-I

Treatment combination	Vigour index-I						
	DAS						
	Initial	30	60	90	120	150	180
M1T1	119.38	130.12	146.65	173.90	200.55	100.32	81.21
M1T2	323.61	325.16	365.86	393.02	433.96	292.54	259.43
M1T3	234.61	244.58	267.42	292.36	327.47	210.14	189.39
M1T4	103.69	112.47	128.63	150.78	178.05	85.40	67.94
M1T5	273.86	287.40	312.57	342.9	380.34	246.53	224.66
M1T6	345.59	353.44	378.68	412.6	456.04	316.93	287.86
M1T7	429.89	440.30	454.99	514.23	552.14	395.89	359.51
M1T8	225.93	232.93	256.55	285.38	313.83	208.27	195.06
M1T9	113.24	121.10	137.17	160.66	189.55	96.41	83.17
M1T10	169.18	177.66	197.33	221.48	246.73	148.26	127.15
M1T11	84.96	89.67	101.96	125.02	151.30	71.60	63.35
M1T12	130.69	134.82	155.60	170.59	194.63	107.92	104.98
M2T1	258.63	256.93	297.74	338.32	389.92	232.18	210.97
M2T2	401.08	436.28	460.01	497.04	548.31	377.29	346.27
M2T3	267.61	300.78	340.78	387.26	454.15	237.60	196.20
M2T4	187.58	194.14	239.28	283.54	341.82	160.41	144.73
M2T5	355.39	365.72	405.02	455.81	542.14	315.03	281.82
M2T6	438.13	461.55	530.54	566.25	647.69	410.03	377.19
M2T7	535.52	562.81	612.05	668.19	713.43	512.36	466.73
M2T8	334.83	350.41	374.87	398.91	445.32	312.63	277.78
M2T9	289.02	294.63	324.30	366.12	399.62	266.49	233.73
M2T10	302.86	318.28	350.37	384.74	425.84	259.91	228.01
M2T11	220.11	250.39	281.15	331.74	369.66	198.10	175.41
M2T12	317.62	337.01	376.40	419.50	455.21	286.13	246.64
M3T1	93.69	109.60	140.89	171.79	206.99	80.08	58.66
M3T2	187.61	193.79	244.85	274.53	277.29	176.63	148.90
M3T3	134.11	167.29	204.00	226.11	271.45	133.91	105.05

Table 49 continued.....

Treatment combination	Vigour index-I						
	DAS						
	Initial	30	60	90	120	150	180
M3T4	69.63	84.43	109.37	140.88	175.27	70.33	51.02
M3T5	154.71	164.92	196.07	236.71	283.50	127.70	102.17
M3T6	224.32	249.48	290.72	339.77	393.23	212.70	185.00
M3T7	314.27	335.32	373.52	428.57	464.92	289.23	242.50
M3T8	161.81	175.72	200.32	233.99	255.25	147.27	116.42
M3T9	105.52	123.51	155.81	186.57	221.35	86.90	66.33
M3T10	163.28	166.09	217.09	248.79	279.12	129.33	107.04
M3T11	105.94	128.82	155.53	188.02	209.26	94.26	79.31
M3T12	127.83	126.04	158.66	189.78	198.39	97.57	79.53
M4T1	90.31	102.09	132.35	158.28	191.34	100.10	73.62
M4T2	145.07	151.24	178.86	201.26	248.14	156.87	104.58
M4T3	91.50	117.39	144.22	155.78	192.79	123.58	79.51
M4T4	47.00	61.53	89.32	117.82	155.23	88.86	66.87
M4T5	133.43	145.88	177.84	217.55	248.41	134.04	111.90
M4T6	195.36	217.63	249.49	279.57	325.51	190.79	155.03
M4T7	256.03	274.52	304.13	341.89	377.29	238.52	207.69
M4T8	146.53	158.53	187.65	225.58	256.74	131.22	84.46
M4T9	108.34	117.51	144.01	172.26	186.71	93.66	88.12
M4T10	111.43	124.09	151.47	177.56	190.07	104.59	82.01
M4T11	43.33	53.09	77.63	100.73	128.75	41.38	30.78
M4T12	76.21	84.08	102.37	128.87	165.45	87.05	60.76
SE $\pm$	13.577	4.640	5.623	5.438	6.877	5.188	4.701
CD @ 5%	37.953	12.970	15.717	15.202	19.222	14.502	13.141

Table 50 Interaction effect of temperature and seed treatments on vigour index-I

Treatment combination	Vigour index-I						
	DAS						
	Initial	30	60	90	120	150	180
C1T1	98.21	108.36	129.86	158.05	187.63	93.05	75.91
C1T2	169.39	198.08	220.22	246.64	279.37	171.38	145.87
C1T3	110.19	136.69	152.15	175.83	224.44	112.09	79.79
C1T4	57.04	68.71	99.30	124.19	156.26	59.35	51.21
C1T5	151.38	161.94	195.12	232.93	289.30	142.55	118.11
C1T6	213.67	229.85	284.56	316.01	375.98	208.58	178.84
C1T7	308.31	326.17	347.19	398.76	440.40	320.75	273.71
C1T8	162.69	174.46	199.37	233.74	266.73	153.56	110.94
C1T9	96.23	110.64	135.70	168.03	186.93	84.69	68.99
C1T10	123.30	145.16	169.53	191.43	214.38	109.36	77.74
C1T11	78.50	89.15	110.61	128.28	155.30	72.88	61.22
C1T12	109.36	116.39	138.27	161.21	173.13	98.46	77.30
C2T1	143.73	152.52	186.24	216.72	254.87	125.67	101.39
C2T2	271.52	265.86	321.74	350.60	401.95	265.50	213.42
C2T3	176.69	197.25	234.74	263.00	305.51	159.88	138.94
C2T4	95.26	113.50	140.75	172.81	215.69	102.72	75.46
C2T5	231.66	240.30	278.95	316.90	361.19	211.95	187.94
C2T6	313.43	332.34	374.37	410.64	446.35	280.34	248.74
C2T7	391.44	414.35	455.56	504.19	540.54	361.17	329.07
C2T8	230.03	245.03	264.15	301.39	322.49	209.86	178.94
C2T9	149.73	163.29	188.88	216.88	248.52	129.05	110.94
C2T10	180.64	190.80	219.04	251.80	278.82	155.26	130.92

Table 50 continued.....

Treatment combination	Vigour index-I						
	DAS						
	Initial	30	60	90	120	150	180
C2T11	118.72	132.76	159.11	195.51	219.47	102.68	86.32
C2T12	160.52	175.07	204.62	233.83	269.69	148.97	125.04
C3T1	179.57	188.18	222.12	256.95	299.09	165.79	141.04
C3T2	352.12	365.92	395.22	427.14	449.46	315.62	285.10
C3T3	258.99	288.59	330.43	357.30	404.44	256.95	208.88
C3T4	153.62	157.21	184.90	222.76	265.83	141.68	121.24
C3T5	305.01	320.72	344.56	389.88	440.31	262.98	234.36
C3T6	375.44	399.38	428.13	471.97	544.51	358.92	326.23
C3T7	452.03	469.19	505.76	561.71	599.89	395.07	354.54
C3T8	259.11	268.70	301.02	322.75	364.14	236.12	215.41
C3T9	216.12	218.63	246.38	279.29	312.47	193.86	173.58
C3T10	256.13	253.63	298.63	331.19	363.12	216.94	199.50
C3T11	143.54	169.56	192.49	235.34	269.46	128.45	114.10
C3T12	219.39	220.00	251.88	286.52	317.44	186.57	166.60
SE $\pm$	11.758	4.018	4.869	4.709	5.955	4.493	4.071
CD @ 5%	32.868	11.232	13.611	13.165	16.647	12.559	11.380

Table 51 Interaction effect of germination methods and temperature on vigour index-I

Treatment combination	Vigour index-I						
	DAS						
	Initial	30	60	90	120	150	180
M1C1	158.75	166.90	184.46	211.78	241.37	139.54	119.36
M1C2	208.51	214.39	239.02	268.60	300.37	184.66	165.38
M1C3	271.39	281.12	302.37	330.37	364.41	245.86	226.17
M2C1	239.20	261.41	301.98	335.63	384.01	218.35	191.16
M2C2	337.69	355.38	393.79	442.32	492.97	304.38	272.34
M2C3	400.20	415.45	452.36	496.40	556.30	369.31	332.87
M3C1	104.65	121.51	149.53	176.15	202.32	113.45	84.65
M3C2	154.74	169.87	211.59	242.08	278.01	135.25	108.82
M3C3	201.29	214.87	250.59	298.15	328.68	162.78	142.01
M4C1	56.82	72.04	91.33	121.50	155.59	70.89	44.70
M4C2	120.18	134.72	164.99	191.76	217.02	126.73	95.83
M4C3	184.13	195.13	228.52	256.02	294.00	175.03	145.81
SE $\pm$	6.789	2.320	2.811	2.719	3.438	2.594	2.350
CD @ 5%	18.977	6.485	7.858	7.601	9.611	7.251	6.570

Table 52 Interaction effect of germination methods, temperature and seed treatments on vigour index-I

Treatment combination	Vigour index-I						
	DAS						
	Initial	30	60	90	120	150	180
M1C1T1	95.70	109.63	132.51	157.29	184.50	85.31	66.63
M1C1T2	212.74	223.79	251.97	280.18	312.37	202.21	178.32
M1C1T3	163.56	169.24	192.12	216.28	254.18	141.24	111.63
M1C1T4	77.30	86.67	106.20	126.04	150.16	58.87	42.75

Table 52 continued.....

Treatment combination	Vigour index-I						
	DAS						
	Initial	30	60	90	120	150	180
M1C1T5	202.98	212.20	237.44	262.68	299.90	176.46	155.26
M1C1T6	261.62	269.92	300.22	329.45	367.73	251.93	215.41
M1C1T7	362.85	375.71	345.44	443.32	469.27	334.31	293.57
M1C1T8	144.44	143.95	167.37	192.98	218.46	118.93	108.67
M1C1T9	96.48	105.32	125.02	145.31	170.64	79.54	70.93
M1C1T10	116.69	122.44	146.26	166.49	191.57	96.67	78.63
M1C1T11	65.98	72.49	75.96	93.94	117.59	49.27	44.21
M1C1T12	104.64	111.48	133.02	127.46	160.06	79.73	66.41
M1C2T1	112.68	121.56	126.27	160.01	188.15	84.22	65.825
M1C2T2	340.46	320.74	382.14	411.77	446.80	283.31	257.28
M1C2T3	228.82	239.93	265.56	288.94	320.09	203.75	189.65
M1C2T4	106.96	115.26	140.38	160.97	192.31	96.83	79.53
M1C2T5	247.34	255.29	283.70	314.54	347.27	221.04	204.15
M1C2T6	341.48	346.39	368.65	407.92	455.56	297.87	267.15
M1C2T7	435.66	443.74	484.26	521.4	566.47	413.48	393.42
M1C2T8	223.30	233.49	252.67	282.92	314.49	223.35	198.63
M1C2T9	108.38	115.82	129.29	166.3	211.15	89.59	80.63
M1C2T10	146.25	154.66	173.55	194.3	217.52	124.41	104.81
M1C2T11	89.36	97.48	117.93	148.86	153.92	75.98	54.92
M1C2T12	121.44	128.29	143.83	165.28	190.66	102.08	88.68
M1C3T1	149.75	159.16	181.17	204.41	229.01	131.44	111.18
M1C3T2	417.63	430.96	463.48	487.11	542.70	392.10	342.7
M1C3T3	311.45	324.56	344.58	371.88	408.13	285.43	266.91
M1C3T4	126.81	135.48	139.30	165.34	191.69	100.51	81.54
M1C3T5	371.25	394.72	416.56	451.48	493.87	342.10	314.58
M1C3T6	433.67	444.02	467.17	500.68	544.84	401.00	381.02
M1C3T7	491.15	501.46	535.26	577.97	620.68	439.87	391.56
M1C3T8	310.04	321.34	349.63	380.25	408.54	282.53	277.89
M1C3T9	134.85	142.16	157.20	170.37	186.85	120.10	97.95
M1C3T10	244.60	255.88	272.19	303.65	331.10	223.69	198.01
M1C3T11	99.54	99.04	111.99	132.26	182.40	89.55	90.93
M1C3T12	165.99	164.68	189.95	219.04	233.16	141.96	159.87
M2C1T1	199.95	197.33	225.81	259.32	292.73	178.56	185.12
M2C1T2	296.95	352.30	354.26	387.75	425.86	291.92	264.03
M2C1T3	161.60	185.74	215.78	242.54	300.65	137.59	111.12
M2C1T4	110.93	132.79	187.27	214.20	248.55	88.00	84.93
M2C1T5	238.25	240.54	294.51	346.54	438.82	208.58	178.83
M2C1T6	327.83	350.56	459.06	494.71	573.83	299.75	268.67
M2C1T7	428.13	456.34	516.56	554.66	597.67	446.47	388.63
M2C1T8	278.25	302.25	335.01	371.63	410.89	251.08	222.03
M2C1T9	197.40	217.54	246.41	281.28	313.96	168.97	150.18
M2C1T10	218.45	241.45	271.87	284.88	342.19	189.34	125.13
M2C1T11	168.30	192.15	219.82	253.54	292.11	143.42	127.43
M2C1T12	244.38	267.94	297.38	336.57	370.88	216.57	187.87
M2C2T1	274.65	275.44	333.26	365.81	425.86	228.74	185.28
M2C2T2	410.00	433.50	470.30	506.59	581.71	379.51	345.13
M2C2T3	265.25	288.64	347.26	401.44	469.63	234.06	204.75
M2C2T4	185.30	206.55	236.06	288.50	345.33	157.07	140.03
M2C2T5	393.40	390.44	427.98	466.24	532.34	358.69	321.33
M2C2T6	458.55	482.84	548.11	586.61	635.96	423.52	391.24
M2C2T7	547.85	572.04	615.83	683.12	732.63	507.55	469.77
M2C2T8	369.05	394.04	401.27	455.43	494.01	339.39	299.32
M2C2T9	262.85	284.70	314.01	346.31	379.06	236.23	209.78

Table 52 continued.....

Treatment combination	Vigour index-I						
	DAS						
	Initial	30	60	90	120	150	180
M2C2T10	300.58	324.14	357.01	414.59	448.70	267.81	238.97
M2C2T11	252.45	271.70	303.86	364.84	408.22	220.28	194.03
M2C2T12	332.33	340.45	370.51	428.40	462.21	299.66	268.53
M2C3T1	301.28	298.03	334.15	389.83	451.17	289.26	262.53
M2C3T2	496.30	523.04	555.46	596.78	637.36	460.43	429.67
M2C3T3	375.98	427.98	459.30	517.79	592.16	341.15	272.73
M2C3T4	266.50	243.09	294.51	347.93	431.59	236.17	209.25
M2C3T5	434.53	466.19	492.58	554.66	655.28	377.82	345.31
M2C3T6	528.00	551.25	584.44	617.44	733.28	506.82	471.67
M2C3T7	630.58	660.04	703.76	766.80	809.98	583.06	541.80
M2C3T8	357.20	354.94	388.32	369.64	431.06	347.42	312.00
M2C3T9	406.80	381.66	412.48	470.78	505.84	394.28	341.23
M2C3T10	389.55	389.24	422.24	454.77	486.64	322.58	319.94
M2C3T11	239.58	287.30	319.78	376.84	408.65	230.59	204.78
M2C3T12	376.15	402.64	461.31	493.52	532.55	342.16	283.53
M3C1T1	56.60	72.13	89.61	109.55	130.86	54.55	26.78
M3C1T2	91.35	125.04	145.58	168.81	192.78	102.82	71.37
M3C1T3	87.45	105.18	125.66	148.05	188.79	113.66	69.25
M3C1T4	39.95	55.39	74.88	95.81	131.76	63.32	50.63
M3C1T5	92.03	109.99	132.47	152.44	209.18	103.00	71.12
M3C1T6	154.23	173.29	214.41	238.71	303.24	177.81	145.82
M3C1T7	255.33	273.38	303.01	351.69	388.66	322.37	259.38
M3C1T8	111.25	122.14	145.69	168.78	190.44	118.68	85.69
M3C1T9	68.55	82.09	114.86	151.31	173.12	52.32	25.53
M3C1T10	130.90	161.43	199.72	223.51	248.26	98.27	82.08
M3C1T11	79.73	91.97	125.78	148.29	173.95	84.35	73.25
M3C1T12	88.43	86.14	122.66	156.88	96.76	70.26	54.93
M3C2T1	94.28	110.43	147.16	181.91	223.28	75.07	57.53
M3C2T2	202.63	167.20	271.71	300.34	351.47	203.50	175.05
M3C2T3	133.83	152.44	195.68	210.44	255.58	112.34	90.87
M3C2T4	59.10	74.07	109.12	146.02	188.93	56.70	27.68
M3C2T5	159.60	177.98	225.23	269.42	320.44	134.85	113.88
M3C2T6	233.25	249.64	300.88	336.94	399.08	202.82	179.55
M3C2T7	314.48	342.21	393.13	446.50	480.30	282.43	231.14
M3C2T8	161.13	177.29	201.44	230.94	222.14	136.07	99.78
M3C2T9	106.70	121.24	143.11	161.67	184.81	89.91	70.37
M3C2T10	158.33	171.54	195.81	224.94	247.82	131.87	100.53
M3C2T11	104.33	133.88	155.93	176.14	198.84	87.37	70.37
M3C2T12	129.20	160.54	199.86	219.70	263.45	110.08	89.14
M3C3T1	130.20	146.25	185.91	223.93	266.82	110.61	91.68
M3C3T2	268.85	289.14	317.26	354.45	287.63	223.58	200.28
M3C3T3	181.05	244.24	290.67	319.87	369.97	175.73	155.03
M3C3T4	109.83	123.84	144.12	180.81	205.14	90.97	74.75
M3C3T5	212.50	206.80	230.52	288.27	320.89	145.26	121.53
M3C3T6	285.48	325.50	356.86	443.65	477.36	257.47	229.62
M3C3T7	373.00	390.37	424.42	487.54	525.80	262.88	236.98
M3C3T8	213.05	227.74	253.83	302.25	353.18	187.07	163.80
M3C3T9	141.30	167.20	209.47	246.75	306.12	118.47	103.08
M3C3T10	200.60	165.29	255.76	297.93	341.29	157.86	138.53
M3C3T11	133.78	160.60	184.87	239.62	255.01	111.07	94.32
M3C3T12	165.88	131.44	153.46	192.77	234.98	112.36	94.53
M4C1T1	40.58	54.34	71.51	106.05	142.43	53.77	25.13
M4C1T2	76.50	91.20	129.07	149.85	186.46	88.57	69.75

Table 45 continued.....

Treatment combination	Vigour index-I						
	DAS						
	Initial	30	60	90	120	150	180
M4C1T3	28.15	86.62	75.04	96.48	154.13	55.87	27.18
M4C1T4	0.00	0.00	28.85	60.74	94.58	27.23	26.56
M4C1T5	72.25	85.01	116.06	170.09	209.31	82.17	67.25
M4C1T6	111.00	125.63	164.56	201.48	259.13	104.83	85.45
M4C1T7	186.93	199.24	223.77	245.39	306.01	179.86	153.28
M4C1T8	116.80	129.49	149.42	201.57	247.13	125.56	27.38
M4C1T9	22.50	37.63	56.53	94.25	90.01	37.94	29.33
M4C1T10	27.15	55.33	60.28	90.87	75.52	53.17	25.13
M4C1T11	0.00	0.00	20.86	17.35	37.56	14.50	0.00
M4C1T12	0.00	0.00	0.00	23.93	64.82	27.27	0.00
M4C2T1	93.30	102.64	138.27	159.17	182.20	114.67	96.95
M4C2T2	133.00	141.98	162.81	183.70	227.83	195.68	76.25
M4C2T3	78.85	107.98	130.45	151.20	176.73	89.39	70.50
M4C2T4	29.68	58.14	77.44	95.75	136.20	100.28	54.63
M4C2T5	126.30	137.48	178.89	217.4	244.71	133.21	112.43
M4C2T6	220.45	250.50	279.85	311.10	294.82	197.17	157.03
M4C2T7	267.78	299.42	329.01	365.75	382.77	241.22	221.97
M4C2T8	166.63	175.32	201.22	236.31	259.32	140.63	118.03
M4C2T9	121.00	131.40	169.13	193.25	219.06	100.46	82.98
M4C2T10	117.40	112.84	149.80	173.39	201.24	96.96	79.38
M4C2T11	28.73	27.99	58.71	92.22	116.91	27.07	25.98
M4C2T12	59.10	71.00	104.31	121.94	162.44	84.07	53.83
M4C3T1	137.05	149.29	187.26	209.63	249.38	131.86	98.79
M4C3T2	225.70	220.54	244.69	270.23	330.13	186.37	167.75
M4C3T3	167.50	157.58	227.18	219.67	247.51	225.47	140.85
M4C3T4	111.33	126.44	161.68	196.98	234.92	139.06	119.43
M4C3T5	201.75	215.15	238.58	265.12	291.20	186.73	156.03
M4C3T6	254.63	276.75	304.06	326.13	422.57	270.38	222.62
M4C3T7	313.40	324.92	359.61	414.53	443.11	294.47	247.83
M4C3T8	156.15	170.79	212.31	238.87	263.78	127.47	107.97
M4C3T9	181.53	183.49	206.38	229.29	251.07	142.57	152.07
M4C3T10	189.75	204.10	244.32	268.43	293.47	163.63	141.53
M4C3T11	101.28	131.29	153.31	192.64	231.78	82.57	66.37
M4C3T12	169.53	181.24	202.81	240.75	269.09	149.82	128.47
SE $\pm$	7.036	8.036	9.739	9.419	11.910	8.986	8.1426
CD @ 5%	20.108	22.464	27.222	26.330	33.293	25.118	22.761

4.2.36 Effect of seed treatment on vigour index-II

The data regarding effect of seed treatments on vigour index-II are presented in Table 53.

From the data, it was revealed that the vigour index-II differed significantly due to different seed treatment during all the periods of storage. It was also noticed that at 120 days the vigour index-II increased up to 12.83 when the seed was treated with 2% KNO₃ (T₇). There was increase in vigour index-

II with the advancement of storage period. The initial vigour index-II was 9.44. After 120 the vigour index-II was decreased during storage. However the untreated seed i.e. control initially showed (3.12) after 120 days it showed maximum vigour index-II (5.45). Vigour index-II reduced rapidly after 180 days of storage and reached 2.38.

4.2.37 Effect of germination methods on vigour index-II

From the data, it was revealed that the different germination methods had significant effect on vigour index-II during all the period of storage. The sand method (M₂) had significantly higher vigour index-II than other during all the period of storage. The initial vigour index-II was (7.27) it was increased up to 120 days (10.18) and at the end of storage period it was decreased to 5.90. The minimum vigour index-II was found in cocopeat method, initially it was (3.12) the vigour index-II increased up to 120 days of storage and at the end of storage period it was 5.82 (Table 54).

4.2.38 Effect of temperature on vigour index-II

The data on effect of temperature on vigour index-II are presented in the Table 54.

It was evident that temperature had significant effect on vigour index-II during all the period of storage. The $30 \pm 2^{\circ}\text{C}$ temperature (C₃) had significantly higher vigour index-II than the other temperature. At initial stage vigour index-II (6.08) was recorded, after 120 days of storage the vigour index-II increased up to (8.88). Vigour index-II was decreased with increased in storage period, it was decreased to (4.96).

4.2.39 Interaction effect of germination methods and seed treatments on vigour index-II

From the data (Table 55), it was observed that, the interaction effect of germination method and seed treatment had significant effect on vigour index-II during all the periods of storage. The interaction of germination in sand and seed treated with 2% KNO₃ (M₂T₇) showed significantly higher vigour index-II than the other interaction. At initial stage vigour index-II was (13.67) recorded, at 120 days of storage vigour index-II was increased (17.70). Vigour index-II was decreased with increased in storage period, at the end of storage period it was decreased to (12.15).

4.2.40 Interaction effect of temperature and seed treatments on vigour index-II

The data on interaction effect of temperature and seed treatments on vigour index-II are presented in the Table 56.

It was observed that the interactions of temperature and seed treatments had significant effect on vigour index-II. Initially the interaction of temperature 30 ± 2°C and seed treated with 2% KNO₃ (C₃T₇) showed significantly higher vigour index-II (11.32). At 120 days of storage the vigour index-II was increased up to 14.93. However the end of storage period of 180 days, the vigour index-II was decreased up to 9.71.

4.2.41 Interaction effect of germination methods and temperature on vigour index-II

From the data (Table 57), it was revealed that the interaction of germination method and temperature had significant effect on vigour index-II during all the periods of storage. The interaction of germination in sand and kept at 30

$\pm 2^{\circ}\text{C}$ for germination (M_2C_3) showed significantly higher vigour index-II (9.26) than the rest of interactions. After 120 days the vigour index-II was increased up to 12.68. The vigour index-II was lowered as increased in storage period, it was decreased to 7.84.

4.2.42 Interaction effect of germination methods, temperature and seed treatments on vigour index-II

The data regarding effect of interaction between germination methods, temperature and seed treatments on vigour index-II are presented in the Table 58.

From the data it was revealed that the interaction of germination methods, temperature and seed treatments on vigour index-II had significant effect on vigour index-II during all the periods of storage. The interaction of germination in sand kept at $30 \pm 2^{\circ}\text{C}$ and seed treated with 2% KNO_3 ($M_2C_3T_7$) showed significantly higher vigour index-II 16.42 at initial stage followed by the interaction of germination in sand kept at $30 \pm 2^{\circ}\text{C}$ and seed treated with 1% KNO_3 ($M_2C_3T_6$) 13.25. The lowest vigour index-II 0.90 was recorded in the interaction of germination in cocopeat kept at $20 \pm 2^{\circ}\text{C}$ with untreated seed i.e. control ($M_4C_1T_1$).

After 120 days of storage the vigour index-II was increased up to (21.00). At the end of storage period, the vigour index-II (14.96) was recorded in the interaction ($M_2C_3T_7$).

Table 53 Effect of seed treatment on vigour index-II

Treatments	Vigour index-II						
	DAS						
	Initial	30	60	90	120	150	180
T1: control	3.12	3.27	4.00	4.66	5.45	2.95	2.38
T2: conc. H ₂ SO ₄ 3 min	5.83	6.12	6.94	7.54	8.49	5.57	4.77
T3: conc. H ₂ SO ₄ 5 min	3.80	4.26	5.07	5.65	6.49	3.68	2.99
T4: conc. H ₂ SO ₄ 10 min	2.24	2.33	3.15	3.85	4.67	2.29	1.83
T5: 1% KH ₂ PO ₄	5.26	5.47	6.33	7.21	8.09	4.74	4.17
T6: 1% KNO ₃	7.28	7.68	8.82	9.81	10.91	6.91	6.14
T7: 2% KNO ₃	9.44	9.77	10.74	12.01	12.83	8.97	8.12
T8: 0.5% Thiourea	4.69	4.86	5.65	6.10	7.31	4.26	3.66
T9: Cow urine	3.31	3.77	4.62	4.69	5.24	2.89	2.49
T10: Mechanical scarification	4.12	4.18	5.03	5.62	6.24	3.57	3.03
T11: Stratification	2.37	2.69	3.22	3.79	4.29	2.16	1.76
T12: Water soaking	3.63	3.48	4.12	4.75	5.25	3.02	2.55
SE $\pm$	0.185	0.048	0.072	0.051	0.078	0.071	0.046
CD @ 5%	0.517	0.135	0.201	0.144	0.220	0.197	0.130

Table 54 Effect of germination methods on vigour index-II

Media	Vigour index-II						
	DAS						
	Initial	30	60	90	120	150	180
M1: Between paper	4.14	4.17	4.65	5.17	5.77	3.66	3.30
M2: Sand method	7.27	7.50	8.50	9.28	10.18	6.62	5.90
M3: Top of paper	3.83	4.16	5.04	5.87	6.64	3.49	2.86
M4: cocopeat	3.12	3.46	4.37	4.91	5.82	3.23	2.58
SE $\pm$	0.106	0.028	0.041	0.029	0.045	0.041	0.026
CD @ 5%	0.298	0.078	0.116	0.083	0.127	0.114	0.075

Table 55 Effect of temperature on vigour index-II

Temperature	Vigour index-II						
	DAS						
	Initial	30	60	90	120	150	180
C1: 20 $\pm$ 2°C	2.95	3.16	3.78	4.38	5.20	2.87	2.33
C2: 25 $\pm$ 2°C	4.74	4.92	5.87	6.55	7.24	4.34	3.69
C3: 30 $\pm$ 2°C	6.08	6.38	7.27	7.99	8.88	5.55	4.96
SE $\pm$	0.092	0.024	0.036	0.025	0.039	0.035	0.023
CD @ 5%	0.258	0.067	0.102	0.072	0.110	0.098	0.065

Table 56 Interaction effect of germination methods and seed treatments on vigour index-II

Treatment combination	Vigour index-II						
	DAS						
	Initial	30	60	90	120	150	180
M1T1	2.62	2.73	3.11	3.64	4.14	2.22	1.82
M1T2	6.05	6.05	6.75	7.27	7.95	5.67	5.13
M1T3	4.40	4.46	4.98	5.51	6.06	3.90	3.55
M1T4	2.19	1.83	2.69	3.13	3.65	1.85	1.47
M1T5	5.33	5.47	6.00	6.56	7.15	4.81	4.33
M1T6	6.41	6.45	6.94	7.55	8.17	5.88	5.38
M1T7	8.03	8.09	8.41	9.47	10.17	6.83	6.76
M1T8	4.29	4.32	4.80	5.33	6.60	3.82	3.47
M1T9	2.42	2.57	2.89	3.27	3.66	2.06	1.77
M1T10	3.47	3.48	3.93	4.39	4.90	2.96	2.52
M1T11	1.73	1.78	2.03	2.42	2.84	1.65	1.18
M1T12	2.75	2.80	3.22	3.51	4.00	2.30	2.19
M2T1	5.14	4.99	5.92	6.56	7.55	4.88	4.18
M2T2	9.16	9.56	10.57	11.12	12.20	8.42	7.69
M2T3	5.78	6.30	7.30	8.30	9.43	5.12	4.33
M2T4	3.99	4.01	5.04	5.97	7.07	3.42	3.00
M2T5	8.07	8.08	9.18	10.35	11.97	7.15	6.45
M2T6	10.66	11.05	12.93	14.06	15.28	10.06	9.25
M2T7	13.67	14.04	15.46	16.91	17.70	13.32	12.15
M2T8	7.79	7.97	8.71	9.25	10.12	7.27	6.56
M2T9	5.55	6.89	7.40	7.01	7.52	5.12	4.43
M2T10	6.53	6.64	7.49	8.22	8.95	5.65	4.97
M2T11	4.09	4.47	5.22	6.03	6.35	3.72	3.24
M2T12	6.87	5.99	6.79	7.56	8.06	5.28	4.56
M3T1	2.29	2.57	3.34	4.15	4.97	1.95	1.45
M3T2	4.52	4.99	5.82	6.61	7.45	4.21	3.55
M3T3	3.00	3.66	4.90	5.21	6.23	2.99	2.32
M3T4	1.59	1.85	2.45	3.15	3.85	1.59	1.12
M3T5	3.69	4.02	4.87	5.64	6.11	3.06	2.45
M3T6	5.95	6.51	7.70	8.85	10.12	5.70	4.92
M3T7	9.04	9.47	10.72	12.22	13.12	9.07	7.75
M3T8	3.80	4.03	4.25	5.35	6.11	3.37	2.67
M3T9	2.50	2.87	3.65	4.39	5.22	2.08	1.59
M3T10	3.95	3.91	5.22	5.95	6.70	3.33	2.71
M3T11	2.61	3.07	3.77	4.27	4.95	2.24	1.86
M3T12	3.01	3.01	3.83	4.60	4.83	2.32	1.90
M4T1	2.42	2.77	3.65	4.29	5.12	2.76	2.07
M4T2	3.60	3.86	4.62	5.18	6.36	3.97	2.72
M4T3	2.03	2.62	3.11	3.57	4.25	2.70	1.77
M4T4	1.22	1.61	2.42	3.16	4.11	2.32	1.75
M4T5	3.95	4.30	5.27	6.30	7.11	3.95	3.43
M4T6	6.12	6.69	7.72	8.78	10.06	6.01	5.03
M4T7	7.01	7.47	8.36	9.43	10.32	6.65	5.80
M4T8	2.90	3.11	4.83	4.45	6.41	2.60	1.94
M4T9	2.76	2.77	4.55	4.10	4.57	2.28	2.19
M4T10	2.51	2.70	3.47	3.94	4.43	2.35	1.90
M4T11	1.06	1.46	1.85	2.41	3.02	1.02	7.83
M4T12	1.89	2.12	2.64	3.35	4.10	2.18	1.55
SE $\pm$	0.371	0.097	0.144	0.103	0.157	0.141	0.093
CD @ 5%	1.035	0.271	0.403	0.289	0.441	0.395	0.261

Table 57 Interaction effect of temperature and seed treatments on vigour index-II

Treatment combination	Vigour index-II						
	DAS						
	Initial	30	60	90	120	150	180
C1T1	1.82	1.97	2.44	2.88	3.43	1.75	1.25
C1T2	3.71	4.01	4.77	5.33	6.00	3.69	3.12
C1T3	2.25	2.66	3.06	3.52	4.36	2.26	1.66
C1T4	1.11	1.28	1.89	2.38	2.98	1.17	1.00
C1T5	3.44	3.59	4.40	5.27	6.43	3.31	2.75
C1T6	4.91	5.18	6.55	7.31	8.61	4.85	4.17
C1T7	7.20	7.45	8.14	9.28	10.25	7.55	6.48
C1T8	3.16	3.25	3.51	4.27	6.46	2.87	2.24
C1T9	1.76	1.91	2.44	3.00	3.46	1.49	1.17
C1T10	2.53	2.85	3.46	3.82	4.43	2.21	1.57
C1T11	1.34	1.45	1.88	2.20	2.62	1.20	9.38
C1T12	2.22	2.31	2.79	3.28	3.44	2.03	1.56
C2T1	3.20	3.35	4.21	4.92	5.74	3.07	2.48
C2T2	5.95	6.24	7.14	7.82	8.78	5.95	4.77
C2T3	3.78	4.12	5.36	5.87	6.64	3.41	2.96
C2T4	2.08	2.11	3.17	3.91	4.77	2.35	1.64
C2T5	5.27	5.41	6.40	7.29	8.12	4.90	4.38
C2T6	7.62	8.07	9.24	9.98	10.76	6.89	6.09
C2T7	9.80	10.23	11.42	12.72	13.31	9.07	8.16
C2T8	5.18	5.45	5.99	6.86	7.40	4.65	4.05
C2T9	3.15	3.36	4.89	4.56	4.96	2.71	2.31
C2T10	4.19	4.30	5.01	5.70	6.18	3.61	3.01
C2T11	2.48	2.84	3.35	4.04	4.40	2.31	1.82
C2T12	4.12	3.60	4.31	4.96	5.77	3.17	2.64
C3T1	4.32	4.48	5.37	6.18	7.18	4.04	3.40
C3T2	7.84	8.10	8.90	9.49	10.68	7.06	6.42
C3T3	5.38	5.99	6.81	7.56	8.48	5.36	4.36
C3T4	3.54	3.58	4.40	5.27	6.27	3.37	2.87
C3T5	7.07	7.41	8.19	9.07	9.71	6.00	5.37
C3T6	9.32	9.78	10.68	12.14	13.36	9.00	8.17
C3T7	11.32	11.62	12.65	14.03	14.93	10.28	9.71
C3T8	5.74	5.87	7.44	7.15	8.08	5.27	4.69
C3T9	5.01	6.04	6.54	6.51	7.31	4.45	4.01
C3T10	5.64	5.40	6.61	7.35	8.12	4.89	4.50
C3T11	3.30	3.79	4.41	5.12	5.85	2.96	2.54
C3T12	4.55	4.54	5.25	6.02	6.54	3.86	3.44
SE $\pm$	0.320	0.084	0.125	0.089	0.136	0.122	0.081
CD @ 5%	0.896	0.235	0.349	0.251	0.381	0.342	0.226

Table 58 Interaction effect of germination methods and temperature on vigour index-II

Treatment combination	Vigour index-II						
	DAS						
	Initial	30	60	90	120	150	180
M1C1	3.37	3.45	3.83	4.37	5.09	3.02	2.61
M1C2	4.02	3.96	4.58	5.11	5.64	3.59	3.18
M1C3	5.03	5.10	5.53	6.04	6.59	4.38	4.11
M2C1	4.82	5.06	6.08	6.68	7.56	4.36	3.73
M2C2	7.75	7.70	8.95	9.71	10.32	6.85	6.13
M2C3	9.26	9.73	10.47	11.44	12.68	8.65	7.84
M3C1	2.40	2.66	3.23	3.91	4.46	2.61	1.93
M3C2	3.97	4.38	5.49	6.20	7.13	3.49	2.81
M3C3	5.12	5.46	6.40	7.48	8.32	4.38	3.83
M4C1	1.23	1.47	1.97	2.56	3.71	1.48	1.04
M4C2	3.21	3.66	4.48	5.19	5.85	3.44	2.65
M4C3	4.93	5.24	6.68	6.99	7.91	4.78	4.05
SE $\pm$	0.185	0.048	0.072	0.051	0.078	0.071	0.046
CD @ 5%	0.517	0.135	0.201	0.144	0.220	0.197	0.131

Table 59 Interaction effect of germination methods, temperature and seed treatments on vigour index-II

Treatment combination	Vigour index-II						
	DAS						
	Initial	30	60	90	120	150	180
M1C1T1	2.16	2.27	2.77	3.23	3.70	2.03	1.66
M1C1T2	4.69	4.62	5.40	5.94	6.51	4.71	4.20
M1C1T3	3.53	3.60	4.18	4.68	5.20	3.06	2.62
M1C1T4	1.60	1.70	2.14	2.55	2.97	1.24	0.90
M1C1T5	4.82	4.92	5.46	6.02	6.60	4.30	3.70
M1C1T6	5.14	5.20	5.74	6.30	6.88	5.00	4.40
M1C1T7	6.90	6.97	6.43	8.22	8.88	6.30	5.72
M1C1T8	3.23	3.33	3.80	4.29	7.20	2.77	2.52
M1C1T9	2.07	2.17	2.56	2.97	3.40	1.70	1.50
M1C1T10	2.56	2.62	3.06	3.51	3.99	2.10	1.70
M1C1T11	1.37	1.45	1.50	1.86	2.24	1.01	0.84
M1C1T12	2.42	2.52	2.96	2.85	3.51	1.98	1.57
M1C2T1	2.41	2.52	2.66	3.31	3.80	1.80	1.40
M1C2T2	6.12	6.15	6.88	7.48	8.10	5.53	5.00
M1C2T3	4.42	4.48	5.12	5.67	6.23	3.90	3.61
M1C2T4	2.20	0.91	2.80	3.24	3.88	1.98	1.60
M1C2T5	4.69	4.75	5.40	5.94	6.51	4.18	3.88
M1C2T6	6.28	6.30	6.82	7.42	8.05	5.46	4.92
M1C2T7	7.93	7.99	8.82	9.50	10.20	7.52	7.13
M1C2T8	4.18	4.25	4.68	5.20	5.74	3.88	3.60
M1C2T9	2.22	2.31	2.62	3.06	3.51	1.81	1.60

Table 59 continued.....

Treatment combination	Vigour index-II						
	DAS						
	Initial	30	60	90	120	150	180
M1C2T10	3.26	3.15	3.60	3.99	4.48	2.70	2.27
M1C2T11	1.80	1.92	2.38	2.80	3.06	2.11	1.12
M1C2T12	2.74	2.85	3.20	3.69	4.20	2.28	2.03
M1C3T1	3.31	3.42	3.90	4.40	4.92	2.85	2.40
M1C3T2	7.36	7.38	7.98	8.38	9.24	6.76	6.20
M1C3T3	5.26	5.32	5.65	6.20	6.76	4.75	4.44
M1C3T4	2.77	2.88	3.14	3.61	4.09	2.34	1.92
M1C3T5	6.50	6.76	7.14	7.74	8.36	5.94	5.40
M1C3T6	7.82	7.87	8.28	8.93	9.60	7.20	6.82
M1C3T7	9.26	9.31	10.00	10.71	11.44	6.68	7.44
M1C3T8	5.46	5.40	5.94	6.51	6.88	4.80	4.29
M1C3T9	2.97	3.23	3.51	3.80	4.09	2.66	2.22
M1C3T10	4.61	4.68	5.12	5.67	6.23	4.09	3.61
M1C311	2.04	1.98	2.21	2.62	3.24	1.81	1.60
M1C312	3.11	3.04	3.51	4.00	4.30	2.66	2.96
M2C1T1	3.05	2.92	3.50	3.57	4.05	2.60	2.18
M2C1T2	6.25	6.66	7.52	8.25	9.00	5.63	5.00
M2C1T3	3.05	3.40	4.05	4.62	5.70	2.55	2.06
M2C1T4	2.05	2.40	3.40	3.93	4.50	1.60	1.55
M2C1T5	5.00	4.87	6.15	7.35	9.13	4.38	3.80
M2C1T6	7.50	7.87	10.57	11.40	12.86	6.75	6.05
M2C1T7	10.65	11.02	12.75	13.65	14.57	11.02	9.64
M2C1T8	5.95	6.33	7.17	7.87	8.60	5.36	4.75
M2C1T9	3.07	3.25	3.85	4.35	4.87	2.60	2.18
M2C1T10	4.25	4.53	5.25	5.40	6.47	3.71	2.40
M2C1T11	2.50	2.70	3.25	3.71	4.20	2.10	1.72
M2C1T12	4.52	4.80	5.52	6.12	6.75	4.00	3.48
M2C2T1	5.55	5.40	6.65	7.31	8.50	5.40	4.37
M2C2T2	9.40	9.77	10.80	11.63	12.60	8.62	7.87
M2C2T3	5.80	6.15	7.52	8.80	9.67	5.12	4.50
M2C2T4	4.00	4.38	5.12	6.30	7.17	3.41	2.85
M2C2T5	9.00	8.80	9.77	10.57	11.50	8.25	0.75
M2C2T6	11.25	11.63	13.38	14.30	14.66	10.43	9.60
M2C2T7	13.95	14.30	15.52	17.18	17.55	13.00	11.87
M2C2T8	8.62	9.00	9.40	10.80	11.16	7.87	7.15
M2C2T9	5.22	5.52	9.80	6.93	7.20	4.67	4.12
M2C2T10	6.67	7.00	7.87	9.13	9.45	6.00	5.36
M2C2T11	4.95	5.20	5.95	7.00	7.22	4.40	3.87
M2C2T12	8.57	5.25	5.62	6.58	7.20	5.03	4.50
M2C3T1	6.82	6.66	7.63	8.80	10.12	6.66	6.00
M2C3T2	11.85	12.25	13.38	13.47	15.00	11.02	10.20
M2C3T3	8.50	9.35	10.35	11.50	12.92	7.70	6.45
M2C3T4	5.92	5.25	6.60	7.70	9.56	5.25	4.61
M2C3T5	10.22	10.57	11.63	13.12	15.30	8.81	8.05
M2C3T6	13.25	13.65	14.85	16.50	18.34	13.00	12.11
M2C3T7	16.42	16.80	18.12	19.91	21.00	15.95	14.96
M2C3T8	8.80	8.57	9.56	9.10	10.60	8.57	7.80
M2C3T9	8.35	11.90	8.55	9.75	10.50	8.10	7.00

Table 59 continued.....

Treatment combination	Vigour index-II						
	DAS						
	Initial	30	60	90	120	150	180
M2C3T10	8.67	8.40	9.35	10.12	10.92	7.24	7.17
M2C3T11	4.82	5.52	6.47	7.40	7.65	4.67	4.12
M2C3T12	7.52	7.92	9.22	9.97	10.25	6.82	5.70
M3C1T1	1.20	1.43	1.80	2.27	2.70	1.15	0.55
M3C1T2	2.25	2.90	3.48	4.00	4.53	2.53	1.75
M3C1T3	1.95	2.24	2.70	3.15	3.98	2.50	1.50
M3C1T4	0.82	1.05	1.43	1.80	2.50	1.31	1.00
M3C1T5	2.25	2.53	3.10	3.60	4.95	2.53	1.81
M3C1T6	3.92	4.25	5.40	6.01	7.60	4.67	3.69
M3C1T7	6.67	7.00	7.87	9.13	9.90	8.50	6.82
M3C1T8	2.17	2.00	1.34	2.87	3.30	2.00	1.42
M3C1T9	1.37	1.62	2.30	3.00	3.43	1.05	0.50
M3C1T10	2.82	3.30	4.22	4.72	5.25	2.10	172
M3C1T11	0.15	1.66	2.47	2.87	3.30	1.42	1.18
M3C1T12	0.19	1.92	2.70	3.50	2.16	1.56	1.20
M3C2T1	2.47	2.80	3.82	4.81	5.85	2.00	1.55
M3C2T2	5.00	5.44	6.66	7.35	8.60	4.87	4.27
M3C2T3	3.05	3.40	5.80	5.55	6.65	2.55	2.06
M3C2T4	1.35	1.62	2.45	3.26	4.12	1.30	0.62
M3C2T5	3.70	4.05	5.22	6.33	7.50	3.15	2.62
M3C2T6	5.92	6.30	7.70	8.43	9.77	5.25	4.61
M3C2T7	9.45	9.93	11.68	13.30	14.25	8.61	7.15
M3C2T8	4.07	4.45	5.08	5.70	6.33	3.50	2.55
M3C2T9	2.37	2.60	3.15	3.62	4.12	2.01	1.56
M3C2T10	4.12	4.45	5.08	5.70	6.30	3.50	2.55
M3C2T11	2.55	3.15	3.75	4.26	4.80	2.10	1.68
M3C2T12	3.60	4.37	5.55	6.17	7.31	3.06	2.55
M3C3T1	3.20	3.48	4.40	5.36	6.37	2.71	2.25
M3C3T2	6.32	6.65	7.31	8.50	9.22	5.22	4.62
M3C3T3	4.02	5.34	6.21	6.93	8.07	3.93	3.40
M3C3T4	2.60	2.90	3.48	4.40	4.95	2.17	1.75
M3C3T5	5.12	5.50	6.30	6.98	5.90	3.50	2.92
M3C3T6	8.00	9.00	10.00	12.11	13.00	7.20	6.46
M3C3T7	11.00	11.47	12.60	14.25	15.22	10.12	9.27
M3C3T8	5.17	5.64	6.33	7.50	8.71	4.62	4.05
M3C3T9	3.77	4.40	5.52	6.56	8.10	3.20	2.71
M3C3T10	4.92	4.00	6.37	7.43	8.55	4.40	3.87
M3C3T11	3.80	4.40	5.10	5.68	6.75	3.20	2.71
M3C3T12	3.50	2.76	3.26	4.12	5.03	2.36	1.95
M4C1T1	0.90	1.25	1.68	2.45	3.26	1.25	0.62
M4C1T2	1.65	1.87	2.70	3.15	3.98	1.87	1.56
M4C1T3	0.50	1.42	1.31	1.65	2.58	0.95	0.47
M4C1T4	0.0	0.00	0.60	1.25	1.95	0.55	0.55
M4C1T5	1.72	2.02	290	4.12	5.03	2.02	1.68
M4C1T6	3.10	3.40	4.50	5.55	7.12	2.97	2.55
M4C1T7	4.57	4.80	5.52	6.12	7.65	4.40	3.75
M4C1T8	1.30	1.35	1.75	2.06	6.75	1.35	0.30
M4C1T9	5.5	0.62	1.05	1.70	2.13	0.62	0.50

Table 59 continued.....

Treatment combination	Vigour index-II						
	DAS						
	Initial	30	60	90	120	150	180
M4C1T10	0.50	0.95	1.31	1.65	2.01	0.95	0.47
M4C1T11	0.00	0.00	0.32	3.5	7.5	0.27	0.00
M4C1T12	0.00	0.00	0.00	6.5	1.35	0.60	0.00
M4C2T1	2.40	2.71	3.71	4.25	4.81	3.10	2.62
M4C2T2	3.30	3.60	4.25	4.81	5.85	4.80	1.93
M4C2T3	1.85	2.45	3.00	3.48	4.00	2.10	1.68
M4C2T4	0.80	1.55	2.31	2.85	3.91	2.71	1.50
M4C2T5	3.70	4.05	5.22	6.33	7.00	4.05	3.50
M4C2T6	7.05	8.06	9.06	9.77	10.57	6.45	5.25
M4C2T7	7.87	8.71	9.67	10.92	11.25	7.17	6.50
M4C2T8	3.87	4.12	4.80	5.77	6.37	3.37	2.90
M4C2T9	2.80	3.03	3.98	4.65	5.03	2.36	1.95
M4C2T10	2.70	2.60	3.50	3.98	4.50	2.27	1.87
M4C2T11	0.65	1.12	1.35	2.10	2.53	0.62	0.60
M4C2T12	1.60	1.93	2.88	3.40	4.37	2.32	1.50
M4C3T1	3.97	4.37	5.55	6.17	7.31	3.93	2.97
M4C3T2	5.85	6.12	6.93	7.60	9.26	5.25	4.67
M4C3T3	3.75	3.98	5.03	5.60	6.18	5.07	3.15
M4C3T4	2.87	3.30	4.37	5.40	6.47	3.71	3.20
M4C3T5	6.45	6.82	7.70	8.43	9.31	5.77	5.12
M4C3T6	8.22	8.62	9.60	11.02	12.50	8.62	7.31
M4C3T7	8.60	8.92	9.90	11.25	12.07	8.40	7.17
M4C3T8	3.55	3.87	7.95	5.52	6.12	3.10	2.62
M4C3T9	4.95	4.65	8.61	5.95	6.56	3.87	4.12
M4C3T10	4.35	4.55	5.62	6.20	6.80	3.85	3.37
M4C3T11	2.55	3.26	3.87	4.80	5.77	2.17	1.75
M4C3T12	4.07	4.44	5.03	6.00	6.60	3.62	3.15
SE $\pm$	0.320	0.168	0.251	0.179	0.272	0.245	0.161
CD @ 5%	0.862	0.471	0.699	0.501	0.762	0.685	0.452

4.2.43 Effect of seed treatment on electrical conductivity (dSm⁻¹)

From the data (Table 60) it was revealed that the electrical conductivity differed significantly due to different seed treatment during all the period of storage. It was noticed that electrical conductivity increased with the advancement of storage period. At initial stage when seed treated with 2% KNO₃ showed minimum (0.391 dSm⁻¹) electrical conductivity than the other treatment. Electrical conductivity increased

with increases in storage period, at the end of storage period it was (0.878 dSm⁻¹) recorded.

4.2.44 Effect of temperature on electrical conductivity (dSm⁻¹)

From the data, it was observed that the temperatures had significant effect on seed electrical conductivity during all the periods of storage. The $30 \pm 2^{\circ}\text{C}$ temperature (C₃) had lowest electrical conductivity as compared to other temperature. At initial stage (0.461 dSm⁻¹) electrical conductivity was recorded after 180 days of storage it was increased up to (0.952 dSm⁻¹) (Table 61)

4.2.45 Interaction effect of temperature and seed treatments on electrical conductivity (dSm⁻¹)

From the data (Table 62), it was observed that, the interaction of seed treatment and temperature had significant effect on electrical conductivity during all the periods of storage. When seed treated with 2% KNO₃ and kept at $30 \pm 2^{\circ}\text{C}$ temperature (C₃T₇) recorded significantly lower electrical conductivity throughout the storage period. At the end of storage period, an electrical conductivity (0.848 dSm⁻¹) was recorded in interaction (C₃T₇).

Table 60 Effect of seed treatments on electrical conductivity (dSm⁻¹)

Treatments	Electrical conductivity (dSm ⁻¹)						
	DAS						
	Initial	30	60	90	120	150	180
T1: Control	0.529	0.627	0.728	0.819	1.005	1.018	1.043
T2: conc.H ₂ SO ₄ 3 min	0.448	0.553	0.647	0.738	0.911	0.924	0.948
T3: conc.H ₂ SO ₄ 5 min	0.483	0.578	0.689	0.781	0.958	0.971	0.996
T4: conc.H ₂ SO ₄ 10 min	0.504	0.600	0.711	0.796	1.011	1.023	1.048
T5: 1% KH ₂ PO ₄	0.445	0.562	0.647	0.742	0.929	0.941	0.968
T6: 1% KNO ₃	0.420	0.508	0.615	0.711	0.883	0.895	0.920
T7: 2% KNO ₃	0.391	0.489	0.588	0.682	0.840	0.852	0.878
T8: 0.5% Thiourea	0.509	0.586	0.714	0.803	0.926	0.938	0.968
T9: Cow urine	0.538	0.631	0.748	0.837	1.028	1.041	1.066
T10: Mechanical scarification	0.493	0.613	0.722	0.813	0.984	0.988	1.017
T11: Stratification	0.518	0.620	0.722	0.813	1.013	1.067	1.089
T12: Water soaking	0.510	0.608	0.718	0.809	0.992	1.016	1.030
SE ±	0.006	0.003	0.003	0.004	0.013	0.013	0.009
CD @ 5%	0.017	0.009	0.008	0.011	0.035	0.037	0.026

Table 61 Effect of temperature on electrical conductivity (dSm⁻¹)

Temperature	Electrical conductivity(dSm ⁻¹)						
	DAS						
	Initial	30	60	90	120	150	180
C1: 20 ± 2°C	0.505	0.599	0.705	0.797	1.009	1.030	1.057
C2: 25 ± 2°C	0.481	0.582	0.688	0.778	0.946	0.962	0.984
C3: 30 ± 2°C	0.461	0.563	0.669	0.761	0.914	0.926	0.952
SE ±	0.003	0.002	0.001	0.002	0.006	0.007	0.005
CD @ 5%	0.008	0.004	0.004	0.005	0.018	0.019	0.013

Table 62 Interaction effect of temperature and seed treatments on electrical conductivity (dSm⁻¹)

Treatment combination	Electrical conductivity (dSm ⁻¹)						
	DAS						
	Initial	30	60	90	120	150	180
C1T1	0.553	0.640	0.745	0.838	1.075	1.087	1.115
C1T2	0.478	0.561	0.668	0.758	0.973	0.985	1.010
C1T3	0.518	0.618	0.723	0.818	1.015	1.027	1.053
C1T4	0.533	0.638	0.738	0.833	1.078	1.089	1.115
C1T5	0.470	0.588	0.675	0.770	0.985	0.998	1.028
C1T6	0.440	0.513	0.641	0.735	0.935	0.948	0.973
C1T7	0.415	0.516	0.613	0.703	0.888	0.901	0.924
C1T8	0.520	0.595	0.723	0.813	0.985	0.998	1.023
C1T9	0.558	0.643	0.753	0.843	1.098	1.110	1.135
C1T10	0.530	0.635	0.733	0.825	1.058	1.045	1.095

Table 62 continued.....

Treatment combination	Electrical conductivity(dSm ⁻¹)						
	DAS						
	Initial	30	60	90	120	150	180
C1T11	0.530	0.630	0.735	0.825	0.993	1.130	1.153
C1T12	0.518	0.613	0.720	0.810	1.030	1.041	1.068
C2T1	0.528	0.633	0.728	0.818	0.985	0.998	1.023
C2T2	0.445	0.546	0.640	0.735	0.898	0.909	0.935
C2T3	0.480	0.568	0.690	0.780	0.945	0.959	0.983
C2T4	0.498	0.593	0.715	0.805	0.995	1.009	1.033
C2T5	0.453	0.570	0.648	0.738	0.918	0.931	0.955
C2T6	0.418	0.513	0.613	0.708	0.860	0.873	0.898
C2T7	0.398	0.485	0.588	0.683	0.825	0.838	0.863
C2T8	0.520	0.593	0.713	0.783	0.913	0.922	0.965
C2T9	0.538	0.631	0.748	0.838	1.005	1.018	1.043
C2T10	0.460	0.623	0.725	0.815	0.965	0.979	0.991
C2T11	0.515	0.624	0.715	0.808	1.030	1.046	1.065
C2T12	0.518	0.611	0.730	0.823	1.018	1.066	1.055
C3T1	0.508	0.609	0.710	0.803	0.955	0.967	0.993
C3T2	0.420	0.550	0.633	0.723	0.863	0.876	0.900
C3T3	0.453	0.548	0.655	0.745	0.915	0.926	0.953
C3T4	0.483	0.571	0.680	0.750	0.960	0.973	0.998
C3T5	0.413	0.528	0.618	0.718	0.885	0.894	0.923
C3T6	0.403	0.500	0.593	0.690	0.853	0.865	0.890
C3T7	0.361	0.465	0.563	0.660	0.809	0.816	0.848
C3T8	0.486	0.570	0.706	0.813	0.880	0.894	0.918
C3T9	0.519	0.620	0.743	0.830	0.983	0.995	1.020
C3T10	0.488	0.583	0.708	0.800	0.930	0.939	0.965
C3T11	0.508	0.608	0.715	0.805	1.015	1.026	1.050
C3T12	0.495	0.600	0.703	0.795	0.928	0.940	0.966
SE ±	0.011	0.006	0.005	0.007	0.004	0.012	0.016
CD @ 5%	0.031	0.016	0.014	0.019	0.011	0.035	0.047

4.2.46 Effect of seed treatment on seed moisture content (%)

From the data (Table 63), it was revealed that the seed moisture content showed significant difference due to different seed treatments during all the period of storage. The moisture content of seeds was highest at initial stage and decreased with increased in storage period.

The initial moisture content (2.48 %) was recorded when seed treated with 2% KNO₃ (T₇). At the end of storage period of 180 days the moisture content decreased up to (1.77 %).

4.2.47 Effect of temperatures on seed moisture content (%)

From the data, it was concluded that the temperatures had significant effect on moisture content during all the periods of storage. Initially the lowest moisture content (2.55 %) was recorded at $30 \pm 2^{\circ}\text{C}$ (C_3) as compared to other temperature. Moisture content decreased with increased in storage period, at the end of storage 180 days (1.91%) was recorded. (Table 64)

4.2.48 Interaction effect of temperature and seed treatments on seed moisture content (%)

From the data (Table 65), it was observed that, the interaction effect of temperatures and seed treatment had significant effect on seed moisture content. The moisture content of seeds was highest at initial stage and decreased during storage period. When seed treated with 2% KNO_3 and kept at $30 \pm 2^{\circ}\text{C}$ temperatures (C_3T_7) recorded significantly lower moisture content throughout the storage period. At the end of storage period, the moisture content (1.79 %) was recorded in interaction (C_3T_7) initially it was (2.47 %) recorded.

Table 63 Effect of seed treatment on seed moisture content (%)

Treatments	Moisture content (%)						
	DAS						
	Initial	30	60	90	120	150	180
T1: Control	2.62 (9.32)	2.60 (9.29)	2.48 (9.07)	2.28 (8.69)	2.14 (8.42)	2.02 (8.18)	1.93 (7.98)
T2: conc.H ₂ SO ₄ 3 min	2.55 (9.19)	2.53 (9.16)	2.42 (8.95)	2.24 (8.60)	2.08 (8.30)	1.96 (8.06)	1.86 (7.84)
T3: conc.H ₂ SO ₄ 5 min	2.57 (9.23)	2.56 (9.20)	2.45 (9.00)	2.31 (8.75)	2.15 (8.44)	2.03 (8.19)	1.93 (8.00)
T4: conc.H ₂ SO ₄ 10 min	2.59 (9.26)	2.57 (9.23)	2.47 (9.05)	2.32 (8.77)	2.17 (8.48)	2.07 (8.28)	1.98 (8.10)
T5: 1% KH ₂ PO ₄	2.54 (9.18)	2.53 (9.16)	2.41 (8.93)	2.26 (8.65)	2.11 (8.35)	2.01 (8.15)	1.91 (7.96)
T6: 1% KNO ₃	2.49 (9.09)	2.48 (9.06)	2.35 (8.82)	2.20 (8.53)	2.04 (8.22)	1.92 (7.96)	1.87 (7.85)
T7: 2% KNO ₃	2.48 (9.07)	2.46 (9.03)	2.32 (8.76)	2.16 (8.46)	2.00 (8.14)	1.87 (7.86)	1.77 (7.65)
T8: 0.5% Thiourea	2.56 (9.21)	2.54 (9.18)	2.41 (8.94)	2.26 (8.65)	2.11 (8.36)	2.01 (8.16)	1.85 (7.80)
T9: Cow urine	2.62 (9.32)	2.59 (9.27)	2.47 (9.04)	2.30 (8.73)	2.15 (8.44)	2.05 (8.24)	1.97 (8.08)
T10: Mechanical scarification	2.59 (9.27)	2.58 (9.25)	2.47 (9.05)	2.31 (8.74)	2.19 (8.51)	2.07 (8.27)	1.98 (8.08)
T11: Stratification	2.62 (9.31)	2.59 (9.27)	2.47 (9.04)	2.30 (8.72)	2.15 (8.44)	2.06 (8.26)	1.98 (8.09)
T12: Water soaking	2.59 (9.27)	2.57 (9.23)	2.45 (9.02)	2.28 (8.68)	2.13 (8.40)	2.05 (8.23)	1.98 (8.09)
SE ±	0.006	0.005	0.006	0.006	0.007	0.006	0.019
CD @ 5%	0.017	0.015	0.017	0.017	0.020	0.017	0.052

Table 64 Effect of temperature on seed moisture content (%)

Temperature	Moisture content (%)						
	DAS						
	Initial	30	60	90	120	150	180
C1: 20 ± 2 °C	2.60 (9.27)	2.58 (9.24)	2.45 (9.00)	2.27 (8.67)	2.12 (8.36)	2.01 (8.15)	1.92 (7.93)
C2: 25 ± 2 °C	2.57 (9.23)	2.55 (9.19)	2.44 (8.99)	2.29 (8.70)	2.13 (8.39)	2.01 (8.16)	1.93 (7.99)
C3: 30 ± 2 °C	2.55 (9.19)	2.54 (9.16)	2.42 (8.94)	2.26 (8.64)	2.12 (8.38)	2.02 (8.16)	1.91 (7.97)
SE ±	0.003	0.003	0.003	0.003	0.004	0.003	0.009
CD @ 5%	0.009	0.008	0.008	0.009	0.010	0.008	0.026

Table 65 Interaction effect of temperature and seed treatments on seed moisture content (%)

Treatment combination	Moisture content (%)						
	DAS						
	Initial	30	60	90	120	150	180
C1T1	2.65 (9.36)	2.63 (9.33)	2.51 (9.11)	2.29 (2.29)	2.13 (8.38)	2.01 (8.15)	1.91 (7.94)
C1T2	2.57 (9.22)	2.56 (9.20)	2.42 (8.95)	2.23 (2.23)	2.07 (8.27)	1.96 (8.05)	1.87 (7.85)

Table 65 continued.....

Treatment combination	Moisture content (%)						
	DAS						
	Initial	30	60	90	120	150	180
C1T3	2.60 (9.29)	2.59 (9.26)	2.46 (9.02)	2.31 (2.31)	2.17 (8.46)	2.03 (8.19)	1.92 (7.95)
C1T4	2.62 (9.31)	2.60 (9.27)	2.48 (9.05)	2.32 (2.32)	2.18 (8.49)	2.06 (8.25)	1.95 (8.02)
C1T5	2.57 (9.22)	2.55 (9.18)	2.42 (8.94)	2.26 (2.26)	2.08 (8.29)	1.99 (8.11)	1.89 (7.91)
C1T6	2.51 (9.11)	2.49 (9.08)	2.36 (8.84)	2.20 (2.20)	2.03 (8.19)	1.91 (7.94)	1.85 (7.82)
C1T7	2.51 (9.11)	2.49 (9.08)	2.33 (8.77)	2.15 (2.15)	1.99 (8.11)	1.86 (7.84)	1.76 (7.61)
C1T8	2.58 (9.25)	2.57 (9.23)	2.44 (8.99)	2.30 (2.30)	2.14 (8.41)	2.04 (8.21)	1.71 (7.44)
C1T9	2.66 (9.38)	2.61 (9.29)	2.47 (9.05)	2.30 (2.30)	2.14 (8.42)	2.07 (8.26)	2.00 (8.13)
C1T10	2.62 (9.32)	2.61 (9.29)	2.49 (9.07)	2.32 (2.32)	2.19 (8.50)	2.07 (8.26)	2.00 (8.13)
C1T11	2.65 (9.37)	2.63 (9.33)	2.50 (9.09)	2.29 (2.29)	2.15 (8.44)	2.07 (8.26)	2.01 (8.14)
C1T12	2.61 (9.30)	2.60 (9.28)	2.48 (9.05)	2.29 (2.29)	2.14 (8.42)	2.06 (8.26)	2.05 (8.23)
C2T1	2.63 (9.33)	2.61 (9.30)	2.49 (9.07)	2.29 (2.29)	2.17 (8.46)	2.01 (8.14)	1.93 (7.99)
C2T2	2.55 (9.18)	2.54 (9.16)	2.44 (8.98)	2.29 (2.29)	2.10 (8.33)	1.97 (8.06)	1.86 (7.84)
C2T3	2.58 (9.23)	2.56 (9.20)	2.47 (9.04)	2.32 (2.32)	2.16 (8.44)	2.02 (8.16)	1.94 (8.01)
C2T4	2.60 (9.27)	2.58 (9.25)	2.51 (9.11)	2.34 (2.34)	2.18 (8.48)	2.08 (8.29)	2.02 (8.16)
C2T5	2.55 (9.18)	2.53 (9.15)	2.41 (8.92)	2.31 (2.31)	2.14 (8.42)	2.03 (8.18)	1.93 (7.98)
C2T6	2.51 (9.11)	2.49 (9.08)	2.37 (8.85)	2.24 (2.24)	2.06 (8.26)	1.92 (7.96)	1.92 (7.94)
C2T7	2.49 (9.08)	2.47 (9.04)	2.34 (8.79)	2.21 (2.21)	2.02 (8.17)	1.88 (7.87)	1.78 (7.67)
C2T8	2.57 (9.22)	2.54 (9.17)	2.43 (8.97)	2.28 (2.28)	2.12 (8.37)	2.01 (8.15)	1.93 (7.98)
C2T9	2.62 (9.32)	2.60 (9.28)	2.49 (9.07)	2.33 (2.33)	2.18 (8.50)	2.07 (8.28)	1.97 (8.06)
C2T10	2.60 (9.27)	2.59 (9.26)	2.47 (9.03)	2.28 (2.28)	2.19 (8.52)	2.10 (8.33)	2.00 (8.14)
C2T11	2.62 (9.31)	2.59 (9.25)	2.47 (9.04)	2.30 (2.30)	2.13 (8.39)	2.06 (8.25)	1.97 (8.06)
C2T12	2.60 (9.27)	2.58 (9.24)	2.46 (9.01)	2.30 (2.30)	2.16 (8.45)	2.06 (8.26)	1.99 (8.10)
C3T1	2.60 (9.28)	2.58 (9.24)	2.47 (9.04)	2.29 (2.29)	2.15 (8.44)	2.06 (8.26)	1.96 (8.04)
C3T2	2.54 (9.17)	2.52 (9.13)	2.41 (8.93)	2.20 (2.20)	2.09 (8.31)	1.98 (8.09)	1.86 (7.83)

Table 65 continued.....

Treatment combination	Moisture content (%)						
	DAS						
	Initial	30	60	90	120	150	180
C3T3	2.56 (9.20)	2.54 (9.16)	2.43 (8.97)	2.31 (2.31)	2.15 (8.42)	2.05 (8.24)	1.96 (8.04)
C3T4	2.56 (9.20)	2.54 (9.17)	2.45 (8.99)	2.32 (2.32)	2.18 (8.49)	2.09 (8.32)	2.00 (8.13)
C3T5	2.53 (9.16)	2.53 (9.16)	2.42 (8.94)	2.23 (2.23)	2.11 (8.35)	2.02 (8.16)	1.93 (7.99)
C3T6	2.49 (9.07)	2.47 (9.04)	2.33 (8.78)	2.18 (2.18)	2.05 (8.23)	1.94 (8.01)	1.85 (7.81)
C3T7	2.47 (9.04)	2.45 (9.00)	2.30 (8.73)	2.14 (2.14)	2.01 (8.15)	1.88 (7.87)	1.79 (7.68)
C3T8	2.55 (9.18)	2.52 (9.14)	2.38 (8.87)	2.23 (2.23)	2.09 (8.31)	2.01 (8.14)	1.94 (8.00)
C3T9	2.60 (9.28)	2.59 (9.25)	2.46 (9.03)	2.29 (2.29)	2.15 (8.43)	2.03 (8.19)	1.97 (8.06)
C3T10	2.58 (9.24)	2.56 (9.21)	2.48 (9.05)	2.34 (2.34)	2.19 (8.51)	2.05 (8.23)	1.94 (8.00)
C3T11	2.60 (9.27)	2.58 (9.24)	2.45 (9.01)	2.31 (2.31)	2.19 (8.51)	2.07 (8.27)	1.97 (8.07)
C3T12	2.58 (9.24)	2.56 (9.20)	2.45 (8.99)	2.26 (2.26)	2.12 (8.36)	2.03 (8.18)	1.92 (7.97)
SE $\pm$	0.011	0.009	0.010	0.005	0.012	0.011	0.032
CD @ 5%	0.031	0.027	0.029	0.015	0.034	0.029	0.090

4.2.49 Effect of seed treatment on seed mycoflora (%)

From the data, it was revealed that seed mycoflora had significant differences due to different seed treatment during all the periods of storage. It was observed that seed mycoflora increased with the advancement of storage period. When the seed treated with conc. H_2SO_4 (T_2, T_3, T_4) no mycofloral growth was seen. Initially control (T_1) i.e. untreated seed showed (20 %) mycoflora and at the end of storage period, it was (70 %) recorded. (Table 66)

4.2.50 Effect of temperature on seed mycoflora (%)

From the data presented in table.67, it was observed that the temperature had significant effect on seed mycoflora during all periods of storage. Initially, lower (8.29 %) seed mycoflora was recorded when seed kept at $20 \pm 2^\circ C$ for

germination. It was observed that seed mycoflora increased with the advancement of storage period. At the end of storage period after 180 days higher (37.08 %) seed mycoflora was recorded at same temperature.

4.2.51 Interaction effect of temperature and seed treatments on seed mycoflora (%)

The data on interaction effect of temperature and seed treatments on seed mycoflora are presented in the Table 68. It was observed that the interactions of temperature and seed treatments had significant effect on seed mycoflora. The seed when treated with conc. H_2SO_4 (T_2, T_3, T_4) and kept at different temperature (20, 25, 30 $\pm$ 2°C) does not showed any mycofloral growth.

Table.66 Effect of seed treatment on Seed mycoflora (%)

Treatments	Seed mycoflora (%)						
	DAS						
	Initial	30	60	90	120	150	180
T1: Control	20.00 (26.06)	26.66 (30.94)	40.00 (39.04)	50.00 (44.97)	55.83 (48.33)	63.33 (52.79)	70.00 (56.84)
T2: conc. H_2SO_4 3 min	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)
T3: conc. H_2SO_4 5 min	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)
T4: conc. H_2SO_4 10 min	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)
T5: 1% KH_2PO_4	11.66 (19.86)	18.33 (24.98)	30.00 (33.20)	35.00 (36.26)	39.58 (38.98)	48.33 (44.04)	53.33 (46.92)
T6: 1% KNO_3	6.66 (12.27)	13.33 (21.32)	20.00 (26.55)	26.66 (31.06)	35.83 (36.65)	40.00 (39.17)	45.00 (42.11)
T7: 2% KNO_3	0.00 (0.00)	10.00 (18.41)	15.00 (22.77)	21.66 (27.70)	26.66 (31.04)	31.66 (34.22)	38.33 (38.22)
T8: 0.5% Thiourea	15.00 (22.58)	20.00 (26.44)	25.00 (29.92)	30.00 (33.15)	35.83 (36.72)	41.66 (40.17)	50.00 (44.99)
T9: Cow urine	26.50 (30.82)	31.66 (34.14)	40.00 (39.21)	46.66 (43.07)	50.41 (45.24)	60.00 (50.79)	66.66 (54.78)
T10: Mechanical scarification	20.00 (26.44)	25.00 (29.92)	33.33 (35.11)	38.33 (38.15)	41.66 (40.16)	48.33 (44.04)	51.66 (45.96)
T11: Stratification	25.00 (29.92)	30.00 (33.15)	35.00 (36.23)	43.33 (41.12)	45.83 (42.59)	51.66 (45.97)	56.66 (48.86)
T12: Water soaking	21.66 (27.51)	26.66 (30.94)	30.50 (33.45)	36.66 (37.20)	40.41 (39.44)	53.33 (46.92)	55.00 (47.88)
SE $\pm$	0.177	0.185	0.176	0.154	0.149	0.147	0.148
CD @ 5%	0.496	0.516	0.493	0.430	0.417	0.411	0.413

Table 67 Effect of temperature on seed mycoflora (%)

Temperature	Seed mycoflora (%)						
	DAS						
	Initial	30	60	90	120	150	180
C1: 20 ± 2 °C	8.29 (12.80)	13.33 (18.50)	18.75 (22.38)	22.92 (25.08)	28.44 (28.44)	32.50 (30.83)	37.08 (33.53)
C2: 25 ± 2 °C	12.50 (16.92)	17.50 (21.46)	22.91 (24.98)	27.91 (28.12)	32.50 (30.84)	38.33 (34.23)	42.08 (36.41)
C3: 30 ± 2 °C	15.83 (19.15)	19.58 (22.60)	25.54 (26.52)	31.25 (29.97)	32.08 (30.52)	38.75 (34.47)	42.50 (36.70)
SE ±	0.089	0.092	0.088	0.077	0.075	0.074	0.074
CD @ 5%	0.248	0.258	0.246	0.215	0.208	0.206	0.206

Table 68 Interaction effect of temperature and seed treatments on seed mycoflora (%)

Treatment combination	Seed mycoflora (%)						
	DAS						
	Initial	30	60	90	120	150	180
C1T1	10.00 (18.41)	20.00 (20.00)	25.00 (30.00)	35.00 (36.27)	48.75 (44.29)	55.00 (47.87)	65.00 (53.73)
C1T2	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)
C1T3	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)
C1T4	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)
C1T5	10.00 (18.41)	10.00 (10.00)	30.00 (33.21)	35.00 (36.27)	40.00 (39.23)	45.00 (42.13)	50.00 (45.00)
C1T6	0.00 (0.00)	15.00 (15.00)	20.00 (26.56)	25.00 (30.00)	33.75 (35.44)	35.00 (36.27)	40.00 (39.23)
C1T7	0.00 (0.00)	10.00 (10.00)	15.00 (22.78)	20.00 (26.56)	26.25 (30.80)	30.00 (33.21)	35.00 (36.27)
C1T8	10.00 (18.41)	15.00 (15.00)	20.00 (26.56)	25.00 (30.00)	32.50 (34.71)	35.00 (36.27)	40.00 (39.23)
C1T9	19.50 (26.20)	25.00 (25.00)	35.00 (36.27)	40.00 (39.23)	46.25 (42.85)	60.00 (50.77)	70.00 (56.79)
C1T10	15.00 (22.78)	20.00 (20.00)	25.00 (30.00)	30.00 (33.21)	36.25 (37.01)	40.00 (39.23)	45.00 (42.13)
C1T11	20.00 (26.56)	25.00 (25.00)	30.00 (33.21)	35.00 (36.27)	41.25 (39.96)	45.00 (42.13)	50.00 (45.00)
C1T12	15.00 (22.78)	20.00 (20.00)	25.00 (30.00)	30.00 (33.21)	36.25 (37.01)	45.00 (42.13)	50.00 (45.00)
C2T1	20.00 (26.56)	25.00 (25.00)	45.00 (42.13)	55.00 (47.87)	60.00 (50.7)	65.00 (53.73)	70.00 (56.79)
C2T2	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.0)	0.00 (0.00)	0.00 (0.00)
C2T3	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)
C2T4	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)
C2T5	10.00 (18.41)	25.00 (25.00)	30.00 (33.21)	35.00 (36.27)	40.00 (39.23)	55.00 (47.87)	60.00 (50.77)

Table 68 continued.....

Treatment combination	Seed mycoflora (%)						
	DAS						
	Initial	30	60	90	120	150	180
C2T6	10.00 (18.41)	15.00 (15.00)	20.00 (26.56)	30.00 (33.21)	45.00 (42.13)	50.00 (45.00)	55.00 (47.87)
C2T7	0.00 (0.00)	10.00 (10.00)	15.00 (22.78)	25.00 (30.00)	30.00 (33.21)	35.00 (36.27)	45.00 (42.13)
C2T8	20.00 (26.56)	25.00 (25.00)	30.00 (33.21)	35.00 (36.27)	40.00 (39.23)	45.00 (42.13)	55.00 (47.87)
C2T9	25.00 (30.00)	30.00 (30.00)	40.00 (39.23)	45.00 (42.13)	50.00 (45.00)	55.00 (47.87)	60.00 (50.77)
C2T10	20.00 (26.56)	25.00 (25.00)	30.00 (33.21)	35.00 (36.27)	40.00 (39.23)	45.00 (42.13)	50.00 (45.00)
C2T11	25.00 (30.00)	30.00 (30.00)	35.00 (36.27)	40.00 (39.23)	45.00 (42.13)	50.00 (45.00)	55.00 (47.87)
C2T12	20.00 (26.56)	25.00 (25.00)	30.00 (33.21)	35.00 (36.27)	40.00 (39.23)	60.00 (50.77)	55.00 (47.87)
C3T1	30.00 (33.21)	35.00 (35.00)	50.00 (45.00)	60.00 (50.77)	58.75 (50.09)	70.00 (56.79)	75.00 (60.00)
C3T2	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)
C3T3	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)
C3T4	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)
C3T5	15.00 (22.78)	20.00 (20.00)	30.00 (33.21)	35.00 (36.27)	38.75 (38.49)	45.00 (42.13)	50.00 (45.00)
C3T6	10.00 (18.41)	10.00 (10.00)	20.00 (26.56)	25.00 (30.00)	28.75 (32.40)	35.00 (36.27)	40.00 (39.23)
C3T7	0.00 (0.00)	10.00 (10.00)	15.00 (22.78)	20.00 (26.56)	23.75 (29.14)	30.00 (33.21)	35.00 (36.27)
C3T8	15.00 (22.78)	20.00 (20.00)	25.00 (30.00)	30.00 (33.21)	35.00 (36.22)	45.00 (42.13)	55.00 (47.87)
C3T9	35.00 (36.27)	40.00 (40.00)	45.00 (42.13)	55.00 (47.87)	55.00 (47.88)	65.00 (53.73)	70.00 (56.79)
C3T10	25.00 (30.00)	30.00 (30.00)	45.00 (42.13)	50.00 (45.00)	48.75 (44.25)	60.00 (50.77)	60.00 (50.77)
C3T11	30.00 (33.21)	35.00 (35.00)	40.00 (39.23)	55.00 (47.87)	51.25 (45.71)	60.00 (50.77)	65.00 (53.73)
C3T12	30.00 (33.21)	35.00 (35.00)	36.50 (37.16)	45.00 (42.13)	45.00 (42.10)	55.00 (47.87)	60.00 (50.77)
SE ±	0.307	0.433	0.305	0.267	0.258	0.255	0.256
CD @ 5%	0.859	1.210	0.853	0.745	0.722	0.712	0.715

4.2.52 Effect of seed treatment on seed weight (g)

From the data, it was revealed that the seed weight differed significantly due to different seed treatment during all the periods of storage. It was noticed that seed weight decreased with increased in storage period. When seed treated with 2% KNO₃ (T₇) showed minimum seed weight (3.39 g) as

compared to other. The seed weight was decreased (2.80 g) after 180 days of storage. (Table 69)

4.2.53 Effect of seed temperature on seed weight (g)

From the data, (Table 70) it was observed that, the different temperatures had significant differences in seed weight. Among the temperatures $30 \pm 2^{\circ}\text{C}$ (C_3) showed lower seed weight as compared to other. At initial stage (3.45 g) seed weight was recorded, after 180 days of storage it decreased up to (2.93g).

4.2.54 Interaction effect of temperature and seed treatments on germination (g)

From the data (Table 71), it was recorded that, the interaction effect of seed treatment and temperature had significant effect on seed weight during all the periods of storage. The seeds when treated with 2% KNO_3 and kept at $30 \pm 2^{\circ}\text{C}$ (C_3T_7) recorded significantly minimum seed weight during all the periods of storage. Initially it was (3.38 g) and decreased with increased in storage period. At the end of storage period (2.80 g) seed weight was recorded.

Table 69 Effect of seed treatment on seed weight (g)

Treatment	Seed weight (g)						
	DAS						
	Initial	30	60	90	120	150	180
T1: Control	3.51	3.49	3.41	3.23	3.09	3.04	2.96
T2: conc. H_2SO_4 3 min	3.44	3.43	3.33	3.14	3.05	2.96	2.87
T3: conc. H_2SO_4 5 min	3.47	3.46	3.38	3.17	3.08	3.02	2.91
T4: conc. H_2SO_4 10 min	3.48	3.47	3.38	3.19	3.12	3.06	2.97
T5: 1% KH_2PO_4	3.44	3.43	3.33	3.16	3.07	2.99	2.92
T6: 1% KNO_3	3.39	3.38	3.27	3.11	3.01	2.92	2.84
T7: 2% KNO_3	3.39	3.37	3.24	3.07	2.97	2.88	2.80
T8: 0.5% Thiourea	3.46	3.45	3.36	3.23	3.07	3.03	2.93
T9: Cow urine	3.51	3.50	3.42	3.26	3.11	3.04	2.96
T10: Mechanical scarification	3.49	3.48	3.38	3.22	3.10	3.02	2.96
T11: Stratification	3.51	3.50	3.41	3.24	3.13	3.09	2.99
T12: Water soaking	3.48	3.47	3.38	3.25	3.13	3.06	3.00
SE $\pm$	0.005	0.003	0.003	0.008	0.012	0.010	0.003
CD @ 5%	0.015	0.009	0.009	0.023	0.034	0.028	0.009

Table 70 Effect of seed temperature on seed weight (g)

Temperature	Seed weight (g)						
	DAS						
	Initial	30	60	90	120	150	180
C1: 20 ± 2 °C	3.49	3.48	3.40	3.22	3.11	3.04	2.96
C2: 25 ± 2 °C	3.46	3.45	3.34	3.19	3.06	3.00	2.91
C3: 30 ± 2 °C	3.45	3.44	3.34	3.16	3.07	2.99	2.93
SE ±	0.003	0.002	0.002	0.004	0.006	0.005	0.002
CD @ 5%	0.008	0.005	0.005	0.012	0.017	0.014	0.005

Table 71 Interaction effect of temperature and seed treatments on seed weight (g)

Treatment combination	Seed weight (g)						
	DAS						
	Initial	30	60	90	120	150	180
C1T1	3.54	3.51	3.44	3.29	3.16	3.08	2.99
C1T2	3.47	3.47	3.38	3.17	3.08	3.01	2.90
C1T3	3.50	3.50	3.41	3.21	3.14	3.09	2.98
C1T4	3.52	3.50	3.44	3.24	3.16	3.12	3.01
C1T5	3.48	3.47	3.38	3.18	3.11	3.02	2.92
C1T6	3.41	3.40	3.31	3.17	3.04	2.96	2.88
C1T7	3.40	3.40	3.28	3.11	2.99	2.91	2.82
C1T8	3.48	3.47	3.37	3.30	3.04	3.03	2.93
C1T9	3.55	3.54	3.48	3.31	3.16	3.09	3.00
C1T10	3.52	3.52	3.42	3.24	3.13	3.07	3.00
C1T11	3.54	3.52	3.45	3.24	3.14	3.07	3.01
C1T12	3.50	3.50	3.42	3.23	3.12	3.07	3.02
C2T1	3.52	3.52	3.42	3.23	3.02	3.02	2.95
C2T2	3.44	3.43	3.32	3.16	3.05	2.95	2.85
C2T3	3.47	3.46	3.37	3.18	3.05	3.00	2.92
C2T4	3.48	3.47	3.34	3.19	3.10	3.06	2.98
C2T5	3.43	3.42	3.30	3.17	3.09	3.00	2.92
C2T6	3.40	3.39	3.26	3.13	3.02	2.94	2.84
C2T7	3.39	3.38	3.24	3.10	2.99	2.88	2.78
C2T8	3.47	3.46	3.35	3.21	3.05	3.01	2.94
C2T9	3.51	3.50	3.39	3.24	3.08	3.01	2.92
C2T10	3.49	3.49	3.36	3.21	3.08	3.00	2.92
C2T11	3.51	3.50	3.41	3.25	3.13	3.15	2.95
C2T12	3.48	3.47	3.37	3.29	3.15	3.06	2.98
C3T1	3.47	3.46	3.38	3.20	3.11	3.02	2.96
C3T2	3.44	3.42	3.31	3.10	3.02	2.94	2.87
C3T3	3.45	3.44	3.36	3.13	3.07	2.98	2.87
C3T4	3.45	3.46	3.38	3.16	3.11	3.01	2.94
C3T5	3.42	3.41	3.32	3.13	3.04	2.97	2.92
C3T6	3.38	3.37	3.26	3.04	2.98	2.90	2.83
C3T7	3.38	3.36	3.22	3.02	2.94	2.85	2.80
C3T8	3.45	3.44	3.36	3.19	3.13	3.05	2.93
C3T9	3.49	3.47	3.41	3.23	3.11	3.02	2.97
C3T10	3.48	3.47	3.38	3.22	3.09	3.02	2.97
C3T11	3.49	3.48	3.38	3.25	3.14	3.07	3.02
C3T12	3.48	3.46	3.36	3.24	3.14	3.07	3.02
SE ±	0.008	0.006	0.006	0.015	0.021	0.017	0.006
CD @ 5%	0.024	0.016	0.016	0.041	0.059	0.048	0.016

5. DISCUSSION

The present investigation was undertaken to standardize seed germination testing procedure of sarpgandha (*Rauvolfia serpentine Benth*). The experiment was conducted during season 2014-2015, at Seed Technology Research Unit (STRU), M.P.K.V., Rahuri and Medicinal and Aromatic Plants Project ('Dhanwantari Garden'), M.P.K.V., Rahuri.

The experiment was conducted in Factorial Completely Randomized Design (FCRD). The different seed treatments employed were chemicals *viz.*, H₂SO₄ for 3 min. (T₂), H₂SO₄ for 5 min. (T₃) and H₂SO₄ for 10 min. (T₄), 1% KH₂PO₄ for 24 hrs. (T₅), 1% KNO₃ for 24 hrs. (T₆), 2% KNO₃ for 24 hrs. (T₇), 0.5% Thiourea for 24 hrs. (T₈) and Cow urine for 5 min. (T₉). Among physical treatments *viz.*, mechanical scarification (T₁₀), cold stratification for 24 hrs. (T₁₁) and water soaking for 24 hrs. (T₁₂) were used in this experiment. The treated seeds were germinated with different methods *viz.*, between paper method (M₁), sand method (M₂), top of paper method (M₃) and cocopeat method (M₁) and germinated at different temperatures *viz.*, 20 $\pm$ 2 °C (T₁), 25 $\pm$ 2 °C (T₂) and 30 $\pm$ 2 °C (T₃) for standardization of germination test.

The seed quality attributes were studied in laboratory. One of the serious hurdles in the commercial cultivation of medicinal crops is low and prolonged period for germination of seeds. The growth regulators were mostly useful for enhancement of the germination of different medicinal plants.

The results obtained on seed germination, growth and seed quality attributes have been discussed under the following subheadings.

5.1 Germination

It is evident from the data that when seed treated with 2% KNO₃ and kept at 30 ± 2°C for germination in sand showed maximum germination in sarpgandha. The seed when soaked in nitrates of potassium increase the permeability of seed coat due to that water enters into the seed, which results in starting of germination activities. Similar result was also reported by Tyagi and Sharma (1977) in *Solanum nigrum*. They showed that, seeds treated with 0.2 per cent KNO₃ improved the germination percentage.

Among the germination methods, sand method (M₂) recorded higher germination. This might be due to rapid exchange of gases between seed and its surrounding for proper germination. The germination method plays an important role in controlling supply of water and exchange of gases. Similar observations were also been made by Singh *et al.* (1976) in *Datura* species. It has been noticed that the 30 ± 2°C temperature was significantly superior over other temperature and recorded the highest germination. This could be owing to high rate of water by seed imbibition at high temperature, since high temperature known to cause increases in kinetic energy of water and decreases of its viscosity.

Similar observation was also reported by Bhagat *et al.* (1992) when seeds of *Ephedra gerardiana* sown in sand medium recorded maximum germination with shortest period

than those sown on soil and filter paper. Interaction effect on germination due to seed treatment, germination methods and temperature was significant. The best combination for interaction was germination in sand at $30 \pm 2^{\circ}\text{C}$ temperature when seed treated with 2% KNO_3 recorded the highest germination.

From the data, it was also revealed that the germination differed significantly due to different seed treatment, germination methods and temperature during all the period of storage. It was noticed that at 120 days the germination was at its highest when seed treated with 2% KNO_3 and kept in sand at 30°C for germination. At the end of the i.e. after 180 days of germination was decreased.

This indicates that various methods respond differently at different temperature and seed treatment with regards to their effect on germination. The storage period also has same impact on germination of sarpgandha.

5.2 Root-shoot length

The root and shoot length of seedling data from result revealed that, there was significant differences in root and shoot length due to different germination methods, temperature and seed treatments. The sand (M_2) germination method and seed treated with 2% KNO_3 and kept at $30 \pm 2^{\circ}\text{C}$ temperature recorded highest root and shoot length than the other combination.

Similar findings had also been made by Bhagat *et al.* (1992), who reported maximum germination and seedling growth in *Woodfordia fruticosa* when seeds sown in sand medium compared to brick media and soil, which registered

58 and 43 %, respectively. Interaction effect on root and shoot length due to seed treatment, germination methods and temperature was significant. The best combination for interaction was germination in sand kept at $30 \pm 2^{\circ}\text{C}$ temperature when seed treated with 2% KNO_3 recorded the highest root and shoot length.

In the present study, the root-shoot length increased progressively up to 120 days of storage, it might be due to completion of resting period of sarpgandha seed. After 120 days of storage the germination, root-shoot length declined progressively with the advancing period of storage. This might be due to ageing of seeds leads to deterioration which causes decrease in germination percentage and root-shoot length.

5.3 Seedling dry weight

From the data it was seen that different seed treatment, germination methods and temperature had significant effect on seedling dry weight. This is because when seed treated with 2% KNO_3 and kept at $30 \pm 2^{\circ}\text{C}$ temperature in sand method for germination which resulted increased seedling dry weight by elongation of root and shoot length. This improvement in root and shoot length of seedling due to nitrates of potassium seed treatment which enhanced metabolic activity, earliness in germination and seedling growth. These results are in conformity with Kattimani *et al.* (2001).

Interaction effect on seedling dry weight due to different seed treatment, germination methods and temperature were significant. The best combination for interaction was sand method at $30 \pm 2^{\circ}\text{C}$ when seed treated

with 2% KNO₃ recorded highest seedling dry weight. This indicates that sarpgandha seed respond differently at different temperature, germination methods and seed treatment.

During the period of storage it was noticed that the seedling dry weight was increased up to 120 days it might be due to the completion of resting period of sarpgandha seed which gave higher germination with higher vigour. At the end of storage period the seedling dry weight was decreased. Similar observation was also reported by Srimati *et al.*, (2003) reported that the dry matter content of seedling decreased with increase in storage period.

5.4 vigour index I and II

Seed vigour is the sum of those properties of seed which determine potential level of activity and performance of seed or seed loss during germination and seedling emergence. It can be measured by root and shoot length, germination percentage and seedling dry weight. The seedling vigour-I is the multiplication of sum of shoot and root length, with germination percentage, whereas, vigour-II is the multiplication of seedling dry weight and germination percentage.

In the present investigation, vigour index-I and II was maximum when seed treated with 2% KNO₃ and kept at 30 ± 2°C temperature in sand method for germination. The interaction effect on vigour index I and II due to different germination methods, seed treatment and temperature were significant.

The seed treatment 2% KNO₃ kept at 30 ± 2°C temperature in sand exhibited highest vigour index I and II, as

a result of higher germination percentage, root-shoot length and dry matter content throughout the storage period.

5.5 Electrical conductivity

The electrical conductivity of seed leachate indicates the membrane integrity and quality of seed and it is negatively correlated with seed quality. In the present investigation there was significant difference in electrical conductivity due to different seed treatment and temperature. Among the seed treatment 2% KNO₃ showed minimum electrical conductivity than the other treatments.

The effect of temperature was also significant. It was observed that electrical conductivity decreases with increases in temperature.

The lowest electrical conductivity was recorded at $30 \pm 2^{\circ}\text{C}$ temperature.

Interaction effect on electrical conductivity due to various seed treatment and temperature were found to be significant. Among the interaction of seed treatment with 2% KNO₃ and kept at $30 \pm 2^{\circ}\text{C}$ temperature recorded lowest electrical conductivity. From the data it was also revealed that the electrical conductivity differed significantly during all the periods of storage. It was noticed that electrical conductivity increased with the advancement of storage period.

5.6 Moisture content

From the data it was seen that different seed treatment had significant effect on moisture content, the lowest moisture content was observed when seed treated with 2% KNO₃. It might be due to the osmosis phenomenon occurs in the seed coat which cause loss of moisture from the seed.

At temperature $30 \pm 2^{\circ}\text{C}$ recorded lowest moisture content because of moisture content decreases with increases in temperature. The seed treatment 2% KNO_3 kept at $30 \pm 2^{\circ}\text{C}$ temperature recorded relatively lower moisture content throughout the storage period. It might be due to effect of potassium salt acting as descant at high temperature.

5.7 Seed mycoflora

Seed mycoflora increased with subsequent increase in storage period. Increased susceptibility of fungal invasion can be correlated with the increased metabolites in seed leachate. Increased leaching from the seed may supply pathogen with a ready source of food for their growth. When seed treated with conc. H_2SO_4 for different duration the mycelia growth was not seen. This could be of great use for raising disease free seedling of sarpgandha.

Seed health testing of seed borne fungal spores indicates the presence of seed borne fungal spores which germinate and produce mycelium under favourable condition. The mycelium growth becomes clearly visible on the seed surface when freshly collected seed were kept at $30 \pm 2^{\circ}\text{C}$ temperature under moist condition. Highest mycelium growth was observed at $30 \pm 2^{\circ}\text{C}$ temperature.

During the period of storage the mycelium growth was increased with increased in the temperature. Interaction effect on seed mycoflora due to different seed treatment was significant. The interaction were seed treated with conc. H_2SO_4 for different period i.e. 3 min., 5 min., 10 min. and kept at 20, 25, $30 \pm 2^{\circ}\text{C}$ did not showed any mycelium growth. Similar observation was also reported by Nautiyal *et al.* (2013) who

conducted the experiment on effect of some pre-soaking scarification treatment on water uptake and germination of *Abrus precatorius*.

5.8 Seed weight

In the present investigation from the data the seed weight showed significant differences seed weight due to different seed treatment. The lowest seed weight was observed when seed treated with 2% KNO₃ and kept at 30 ± 2°C. This might be due to when seed treated with nitrates of potassium it enters in to the seed coat and remove moisture from the seed by the osmosis phenomenon. This removal of moisture from seed decreases its weight.

During the storage seed weight slowly declined up to 180 days of storage, at the end of storage the moisture content of seed was decreased.

6. SUMMARY AND CONCLUSION

The present investigation was undertaken to standardize seed germination testing procedure of sarpgandha (*Rauvolfia serpentina*). The experiment was conducted during the year 2014-2015, at Seed Technology Research Unit (STRU), M.P.K.V., Rahuri. and Medicinal and Aromatic Plants Project ('Dhanwantari Garden'), M.P.K.V. Rahuri.

The sarpgandha seeds were treated with different treatments i.e. chemicals *viz.*, H₂SO₄ for 3 min. followed by shade drying (T₂), H₂SO₄ for 5 min. followed by shade drying (T₃) and H₂SO₄ for 10 min. followed by shade drying (T₄), 1% KH₂PO₄ for 24 hrs. followed by shade drying (T₅), 1% KNO₃ for 24 hrs. followed by shade drying (T₆), 2% KNO₃ for 24 hrs. followed by shade drying (T₇), 0.5% Thiourea for 5 min. followed by shade drying (T₈) and Cow urine for 5 min. followed by shade drying (T₉) and physical *viz.*, mechanical scarification with sand paper (T₁₀), cold stratification for 24 hrs. followed by shade drying (T₁₁), water soaking for 24 hrs. followed by shade drying (T₁₂), along with control i.e. untreated seeds (T₁) were used for experiments.

The treated seeds were germinated with different methods *viz.*, between paper method (M₁), sand method (M₂), top of paper method (M₃) and cocopeat method and temperatures *viz.*, 20 ± 2 °C (T₁), 25 ± 2 °C (T₂) and 30 ± 2 °C (T₃) were used for standardization of germination test. The experiment was conducted in Factorial Completely Randomized Design (FCRD)

with four replications to assess the suitable method, temperature and treatment for germination.

The observation of seed quality attributes were recorded *viz.*, germination (%), root length (cm), shoot length (cm), dry matter content of seedling (mg), vigour index-I, vigour index-II, seed mycoflora (%), moisture content (%), electrical conductivity (dsm^{-1}), 100 seed weight.

6.1 Summary

The important findings of the investigation are summarized, as below.

6.1.1 Germination

The sarpgandha seed exhibited consistently higher germination when seed treated with 2% KNO_3 than the other treatments. The sand method recorded highest germination when kept at $30 \pm 2^\circ\text{C}$ temperature under the studies. During 180 days of storage period 2% KNO_3 seed treatment kept at $30 \pm 2^\circ\text{C}$ in sand for germination ($\text{M}_2\text{C}_3\text{T}_7$) recorded consistently higher germination than the other treatment, germination methods and temperature. Therefore, 2% KNO_3 seed treatment, sand method and $30 \pm 2^\circ\text{C}$ temperature was found suitable for germination of sarpgandha seed.

6.1.2 Root and shoot length

The seed treated with 2% KNO_3 and kept at $30 \pm 2^\circ\text{C}$ temperature in sand showed consistently higher root-shoot length as its germination was higher. In the storage condition the seed when treated with 2% KNO_3 kept at $30 \pm 2^\circ\text{C}$ temperature

in sand exhibited consistent high root-shoot length than other combinations.

6.1.3 Seedling dry weight

The seedling dry weight exhibited significantly higher value in the seed treatment 2% KNO₃, as its root-shoot length was higher than others. During 180 days of storage period 2% KNO₃ seed treatment kept at $30 \pm 2^{\circ}\text{C}$ in sand for germination (M₂C₃T₇) recorded consistently higher Seedling dry weight than the other treatments, germination methods and temperature.

6.1.4 Vigour index I and II

The seed treated with 2% KNO₃ and kept in sand method at $30 \pm 2^{\circ}\text{C}$ temperature exhibited consistently higher vigour index. than the other treatments and germination methods and temperature combination . Same trend was observed during storage where seed treated with 2% KNO₃ kept at $30 \pm 2^{\circ}\text{C}$ temperature in sand method recorded higher vigour index.

6.1.5 Electrical conductivity

The seed treated with 2% KNO₃ showed consistently lower electrical conductivity, as it had higher germination than the other treatment. The $30 \pm 2^{\circ}\text{C}$ temperature recorded lowest electrical conductivity than the other temperature. The seed treated with 2% KNO₃ and kept at $30 \pm 2^{\circ}\text{C}$ showed consistently lower electrical conductivity throughout the storage period, as it had higher germination percentage.

6.1.6 Moisture content

Moisture content of 2% KNO₃ treated seed and 30 ± 2°C temperature showed statistically significant results. The moisture content was higher when fresh seed was collected from the field. The seed treated 2% KNO₃ showed lower moisture content than the other treatments as it had higher germination. It was observed that the moisture content decrease with increase in storage period.

6.1.7 Seed mycoflora

In acid scarification i.e. when seed was treated with conc. H₂SO₄ for different periods i.e. 3 min, 5 min, 10 min and kept at 20, 25, 30 ± 2°C temperature mycelium growths was no seen. It was also observed that mycelium growth increases with increases in temperature. Same trend was when seed treated with conc. H₂SO₄ did not showed any mycelium growth during the period of storage.

6.1.8 Seed weight

The seed treated with 2% KNO₃ showed lower seed weight as it had higher germination than the other treatments. The temperature had significant effect on seed weight; it was observed that seed weight decreases with increase in temperature. At initial stage the seed weight was higher as it contained maximum moisture content. The moisture content decreases with increase in storage period.

6.2 Conclusion

The following broad conclusions are drawn from the present studies

- It is concluded that the seed treated with 2% KNO₃ is the best seed treatment for successful establishment of sarpgandha seedlings which gave highest germination percentage.
- The seed treated with different chemicals *viz.*, 2%, KNO₃ and 1% KNO₃ increased the root and shoot length.
- The sand method was suitable method to use for seed germination test for getting the higher germination percentage.
- The temperature 30 ± 2°C is ideal for increased seed germination.
- The seeds treated with 2%, KNO₃ and kept in sand method at 30 ± 2 °C are the ideal conditions for higher germination. However where the seed was treated with conc. H₂SO₄ the mycelia growth was not seen. This could be of great use for raising the disease free seedling.
- It was noticed that at 120 days the germination was at its highest when seed treated with 2% KNO₃ and kept in sand at 30°C for germination. At the end of the i.e. after 180 days of germination was decreased.

The above mentioned conclusions are based on the results of one season experiment and needs further experiment to conform the suitable method for germination and accurate benefits.

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8. V I T A

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A candidate for the degree

Of

MASTER OF SCIENCE (AGRICULTURE)

In

AGRICULTURAL BOTANY

(SEED SCIENCE AND TECHNOLOGY)

2015

Title of Thesis : “Standardization of seed germination testing procedure in Sarpagandha (*Rauvolfia serpentina* Benth)”

Major Field : Seed Science and Technology

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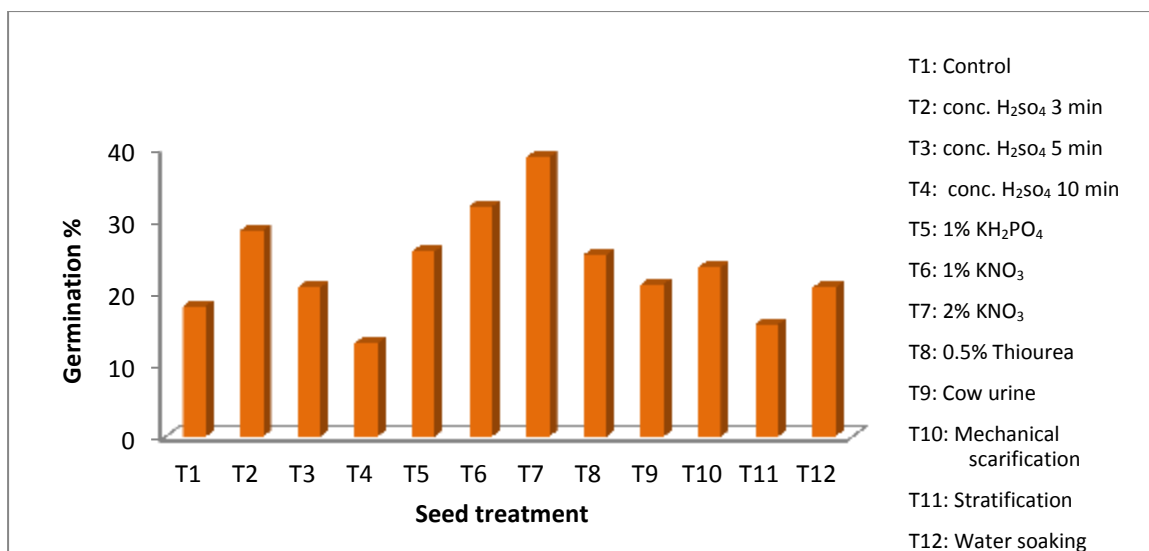


Fig 1 Effect of seed treatments on germination %

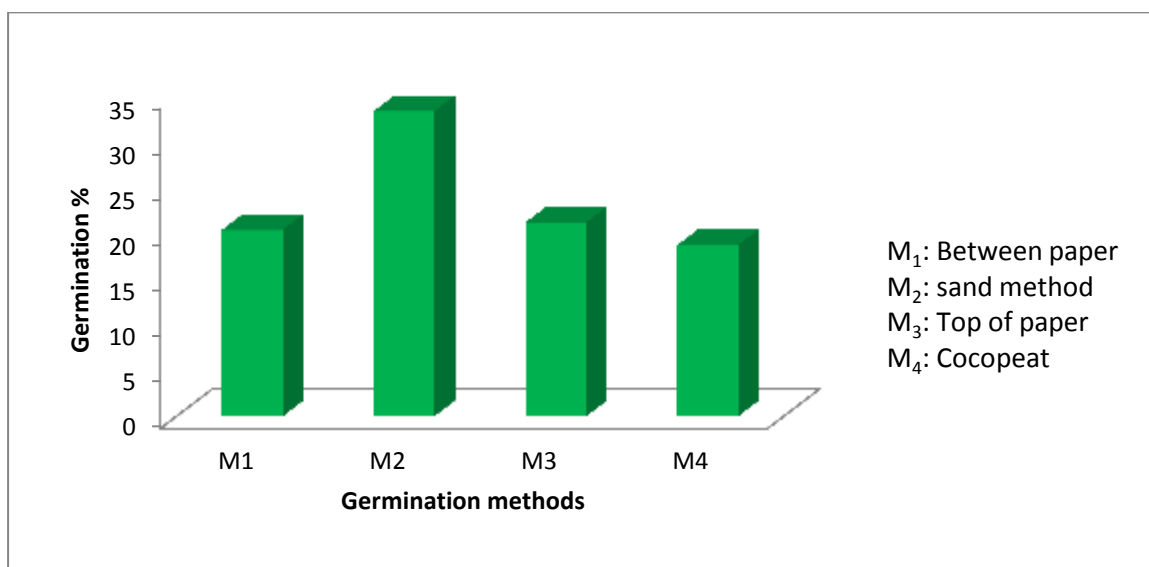


Fig 2 Effect of germination methods on germination %

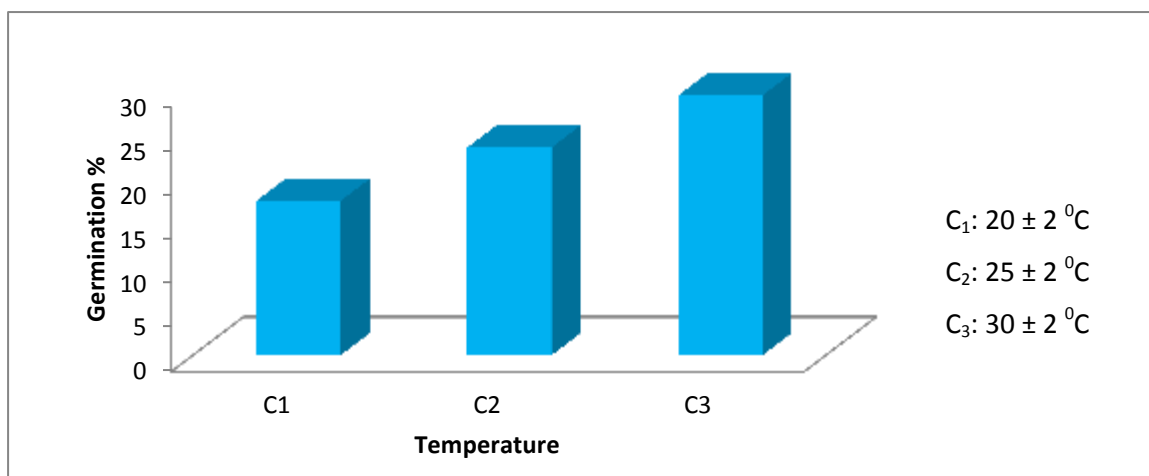


Fig 3 Effect of temperature on germination %

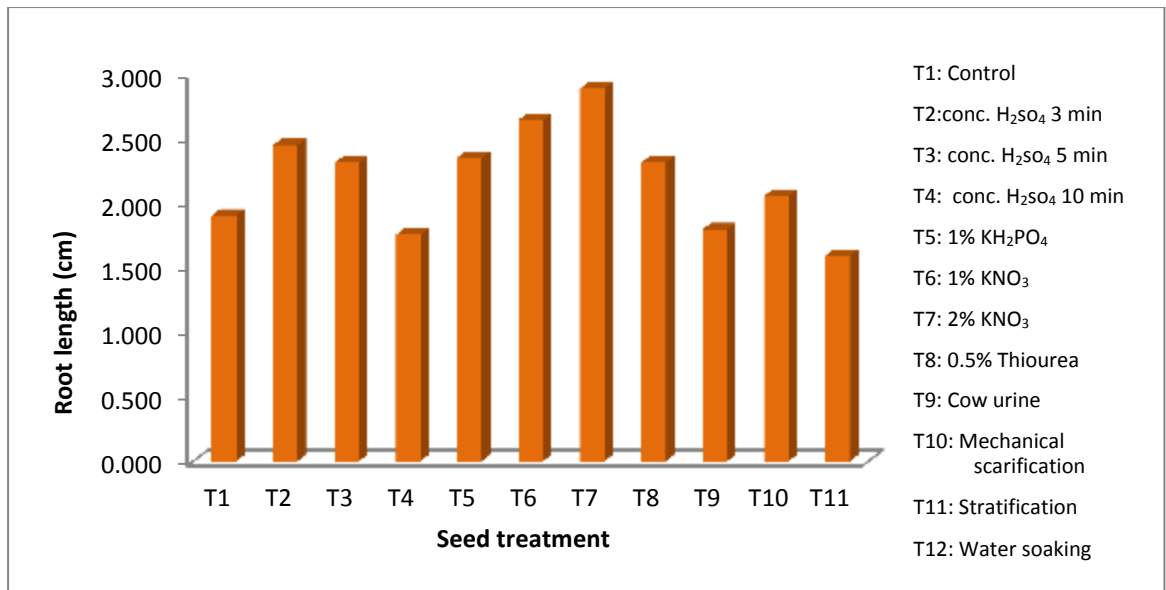


Fig 4 Effect of seed treatment on root length (cm)

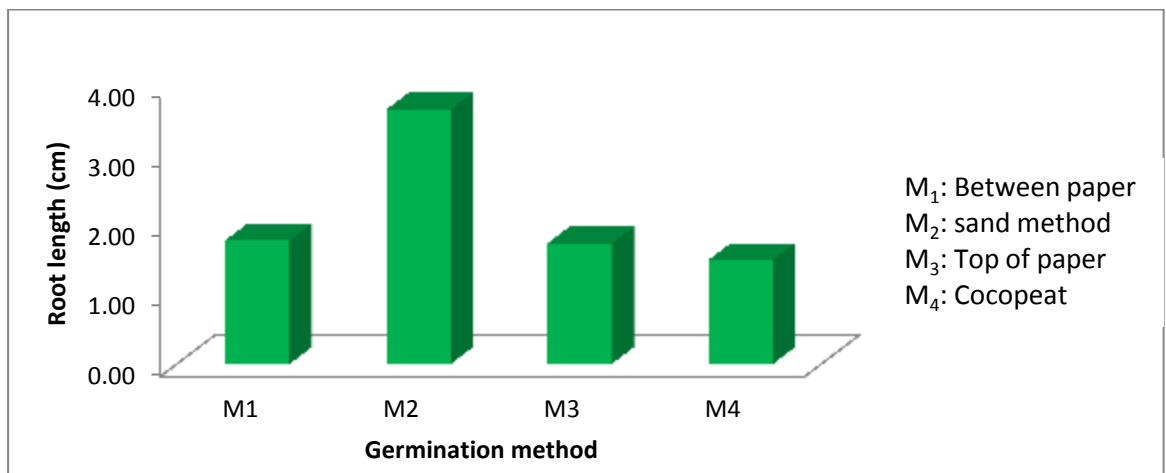


Fig 5 Effect of germination method on root length (cm)

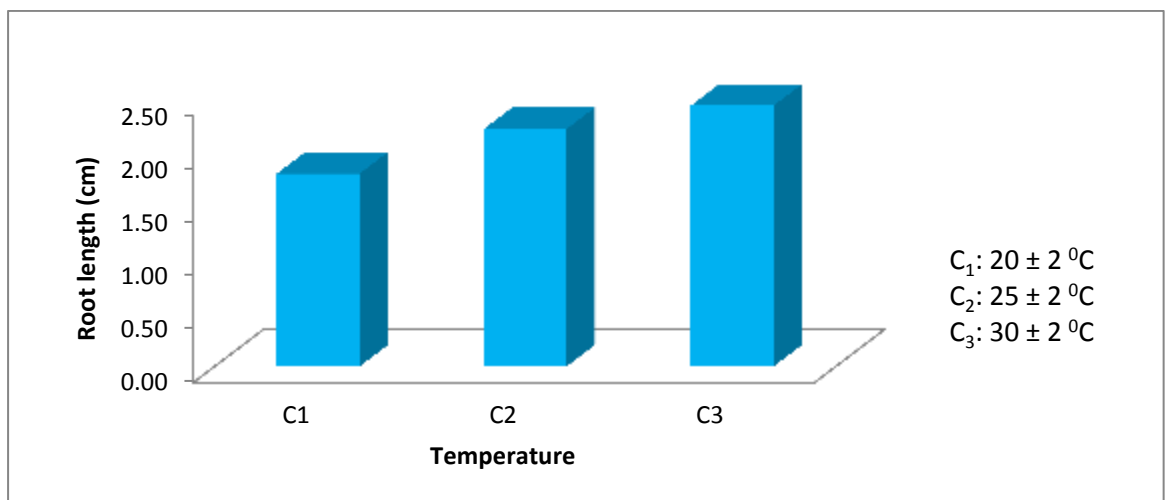


Fig 6 Effect of temperature on root length (cm)

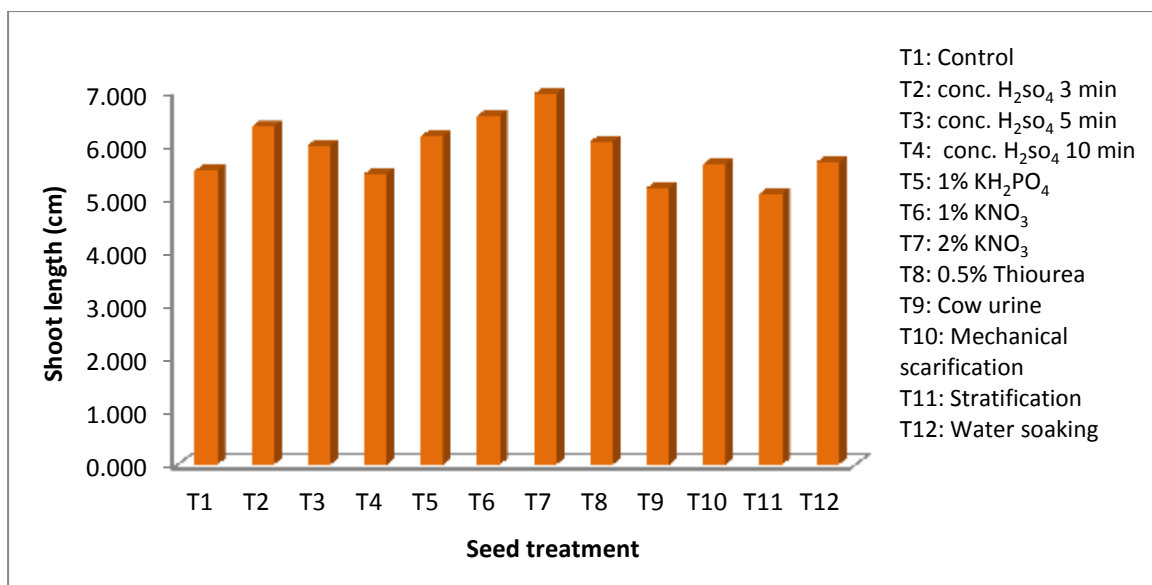


Fig 7 Effect of seed treatment on shoot length (cm)

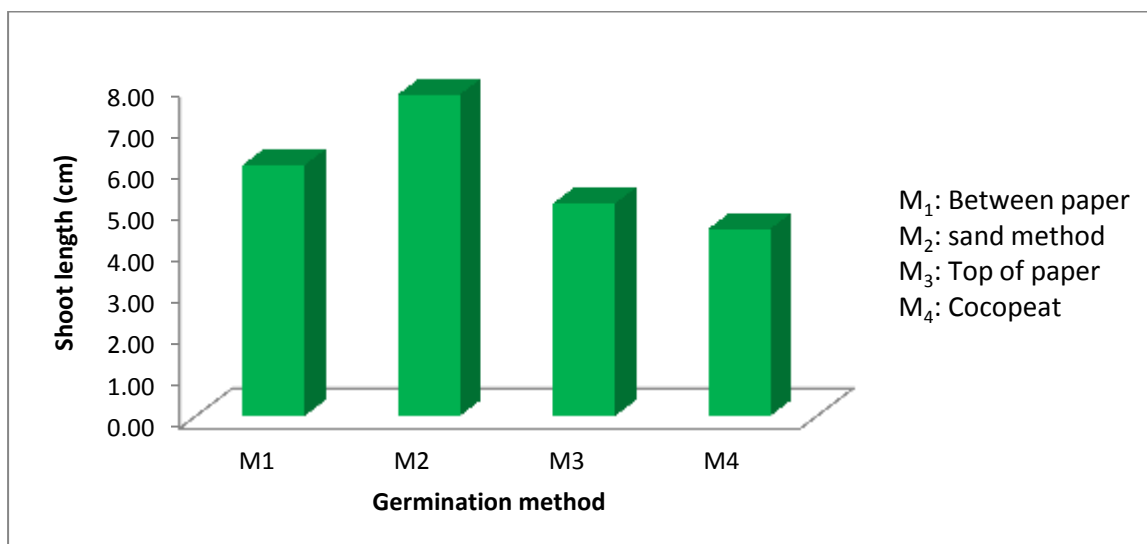


Fig 8 Effect of germination method on shoot length (cm)

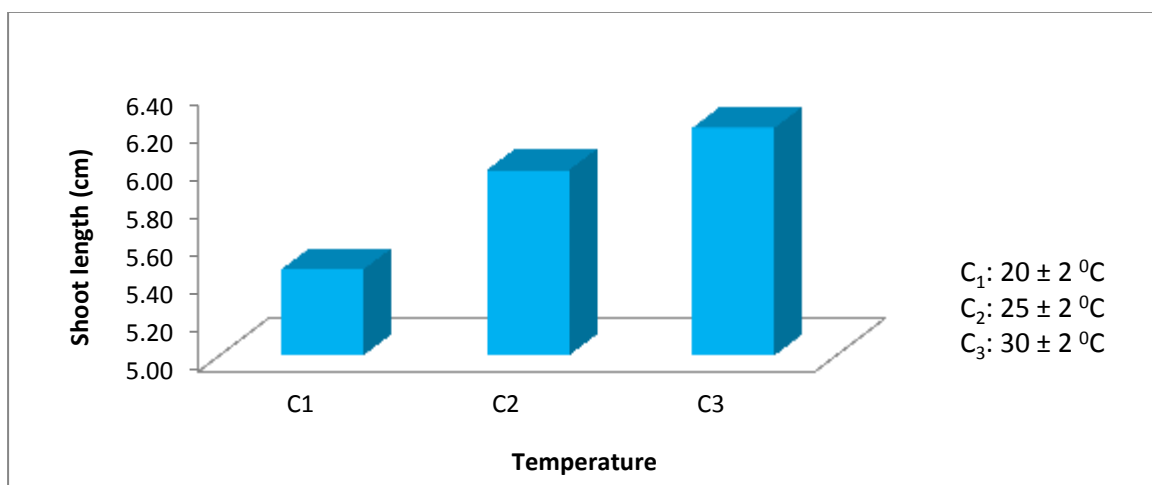


Fig 9 Effect of temperature on shoot length (cm)

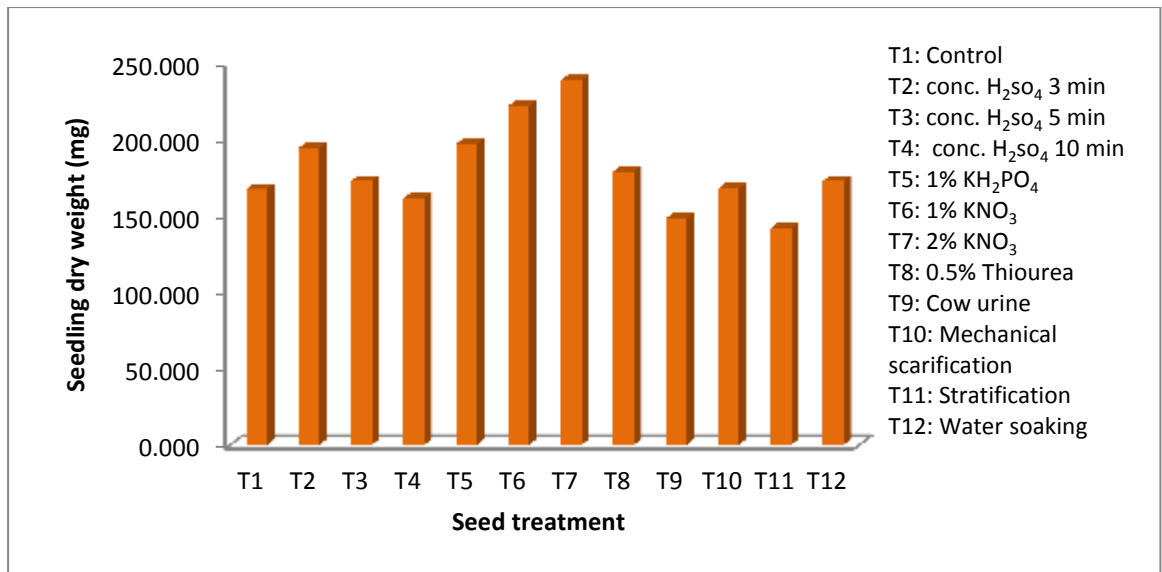


Fig 10 Effect of seed treatment on seedling dry weight (mg)

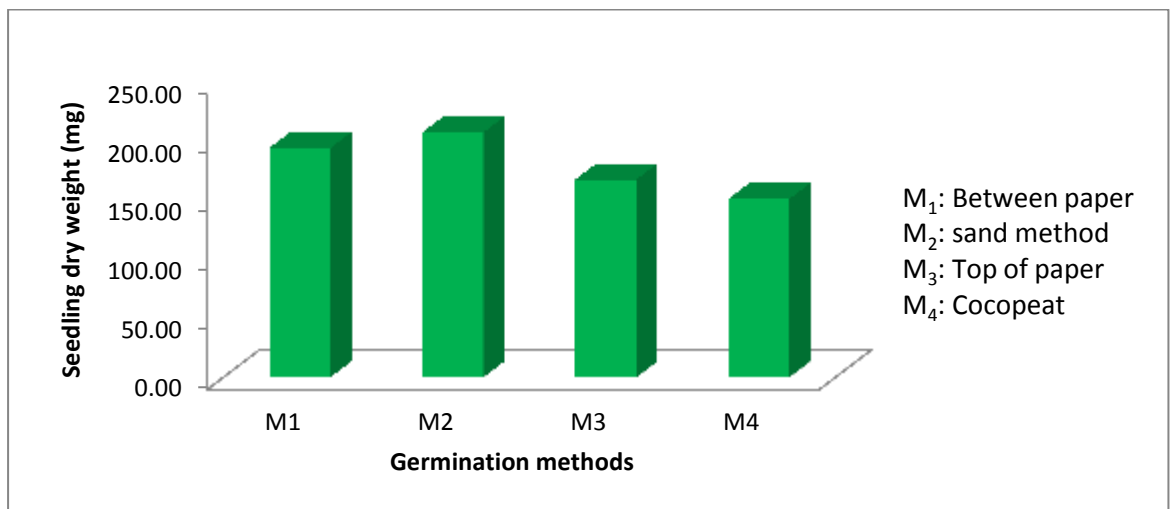


Fig 11 Effect of germination method on seedling dry weight (mg)

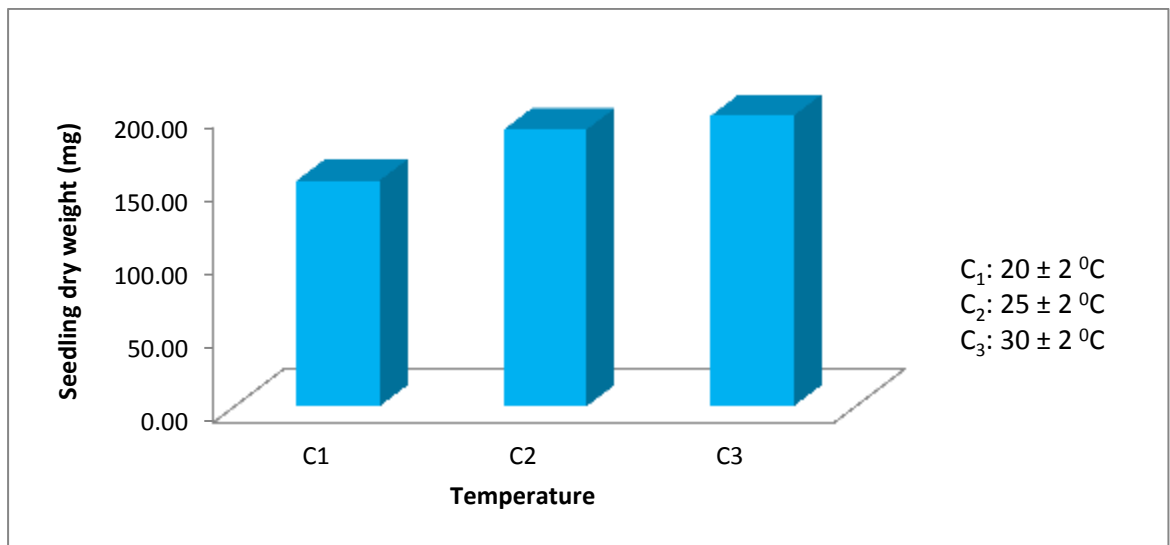


Fig 12 Effect of temperature on seedling dry weight (mg)

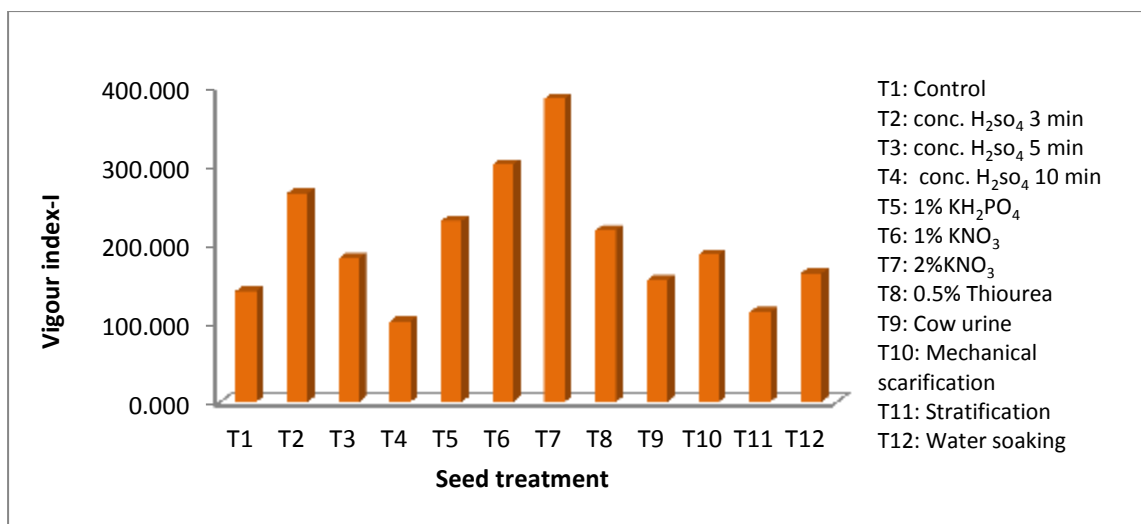


Fig 13 Effect of seed treatment on vigour index-I

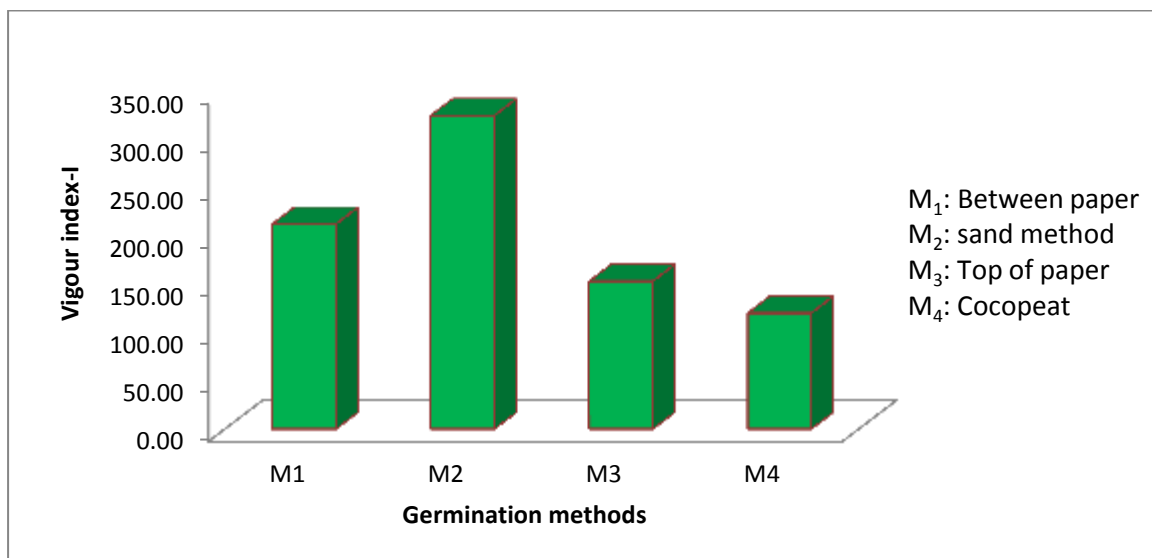


Fig 14 Effect of germination method on vigour index-I

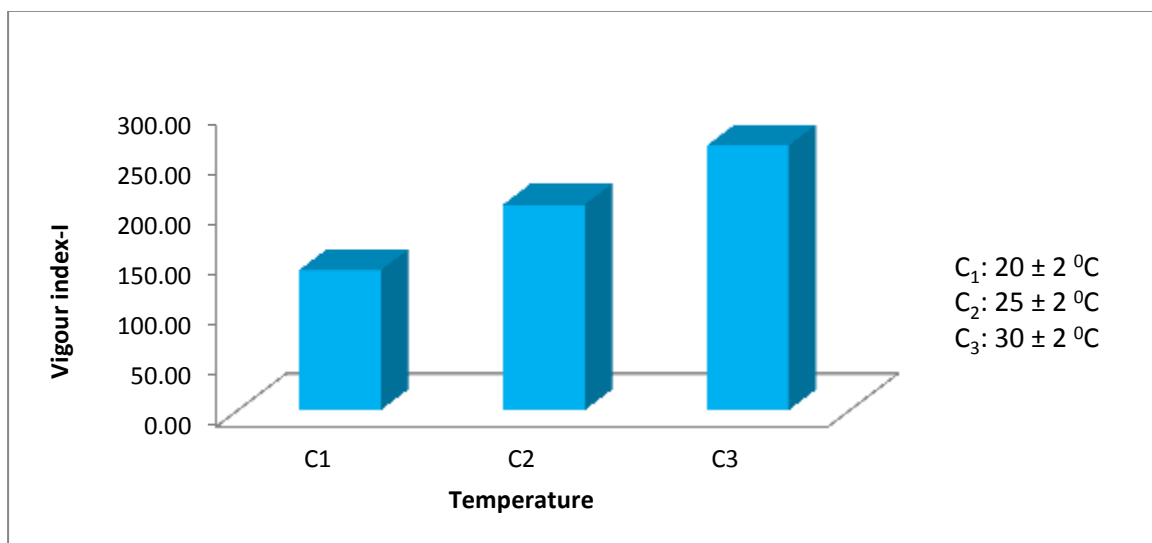


Fig 15 Effect of temperature on vigour index-I

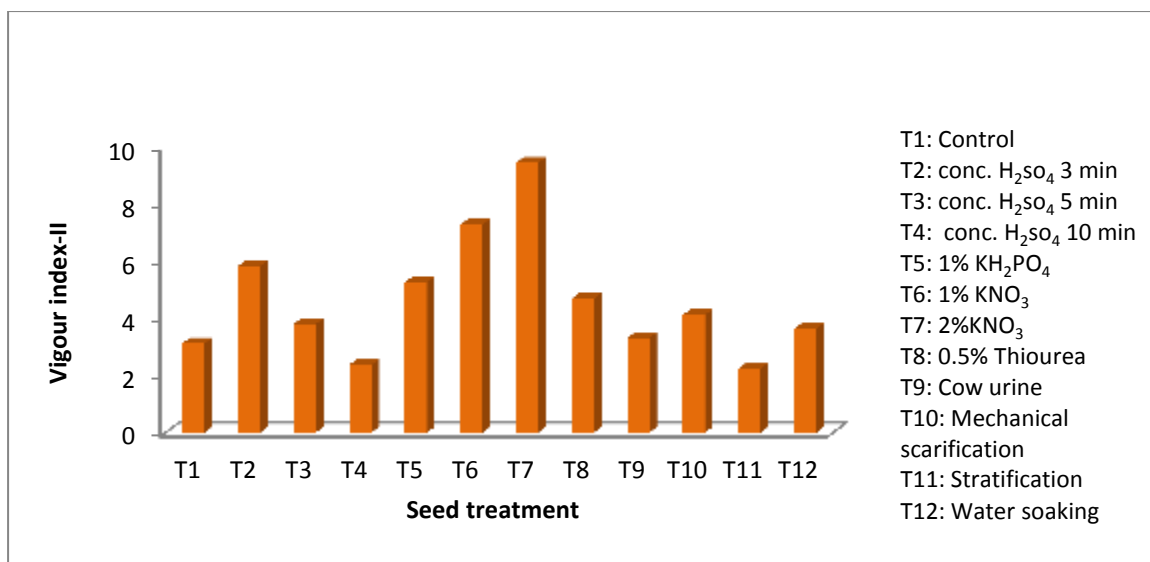


Fig 16 Effect of seed treatment on vigour index-II

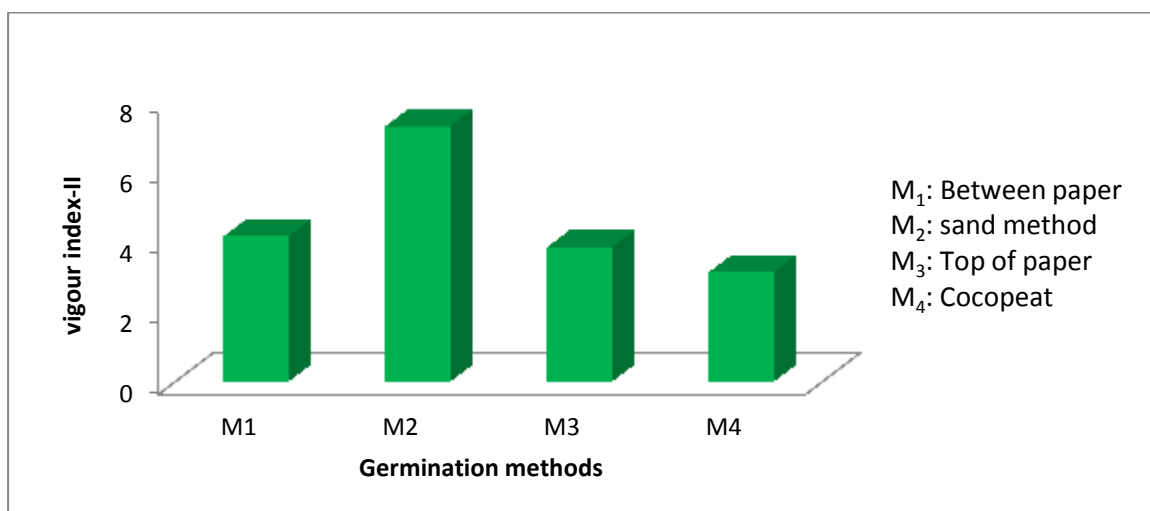


Fig 17 Effect of germination method on vigour index-II

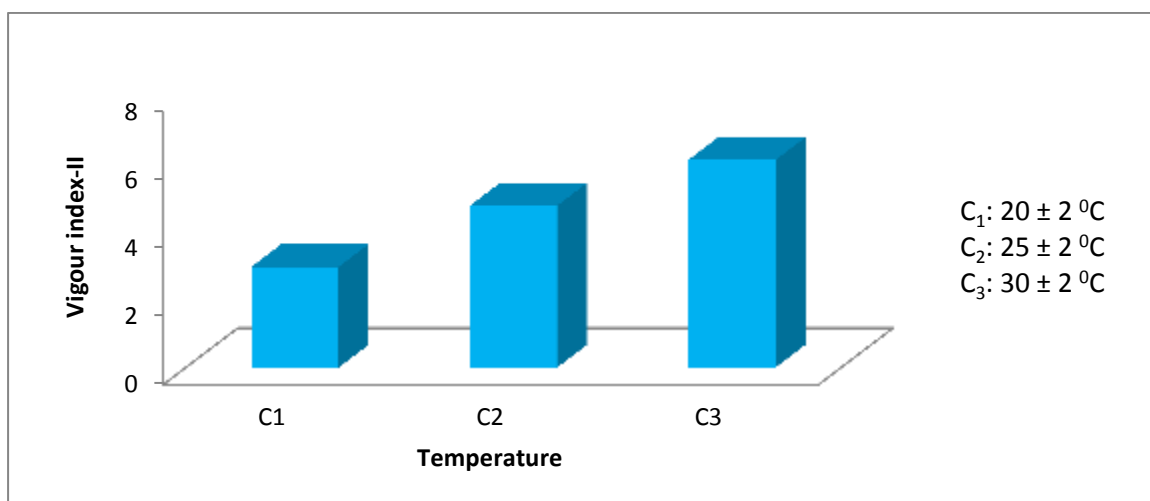


Fig 18 Effect of temperature on vigour index-II

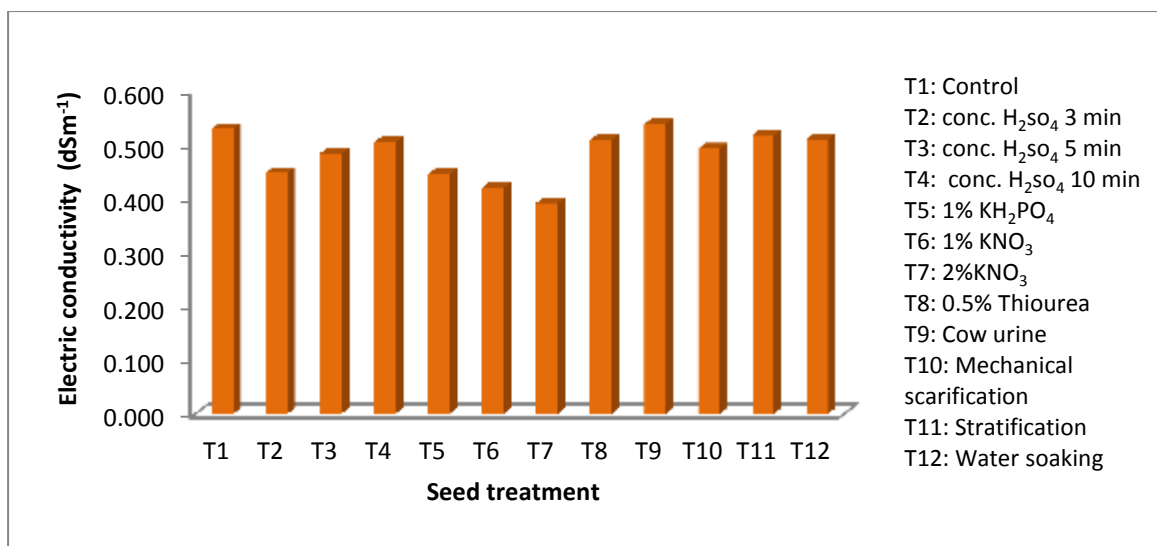


Fig 19 Effect of seed treatment on electric conductivity (dSm^{-1})

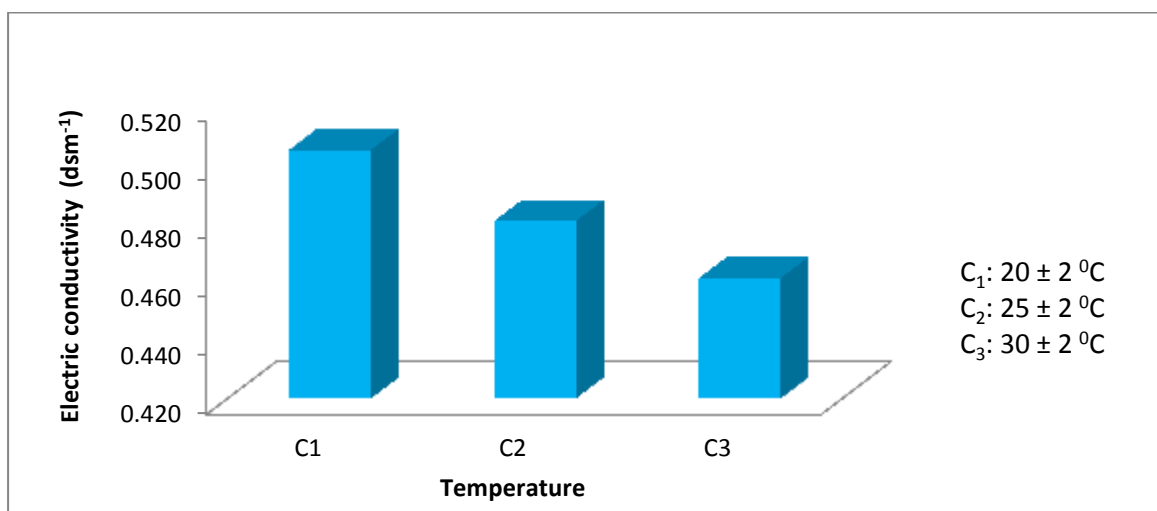


Fig 20 Effect of temperature on electric conductivity (dSm^{-1})

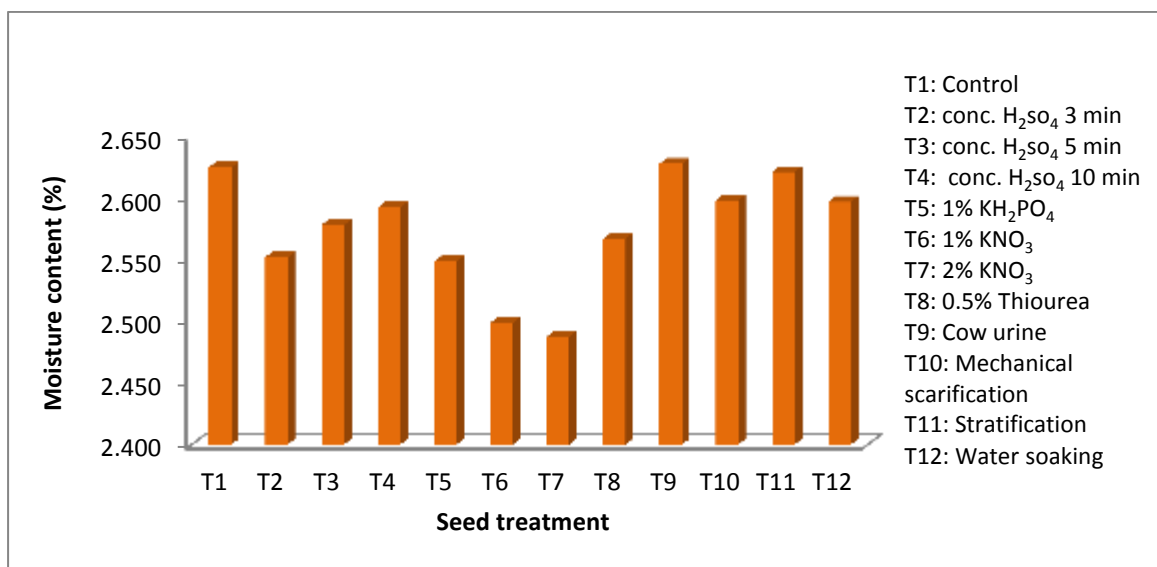


Fig 21 Effect of seed treatment on moisture content (%)

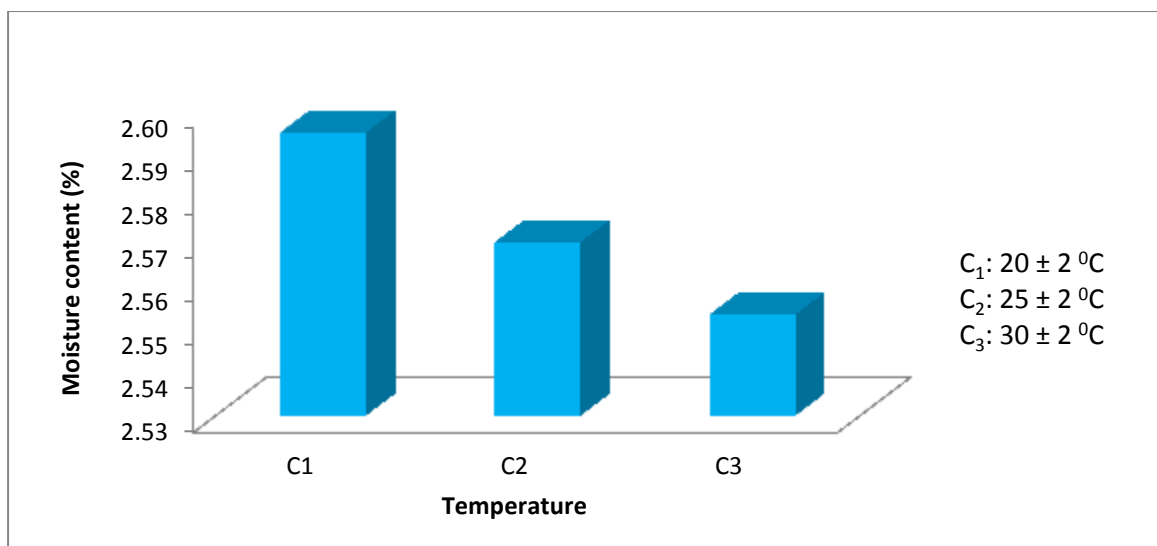


Fig 22 Effect of temperature on moisture content (%)

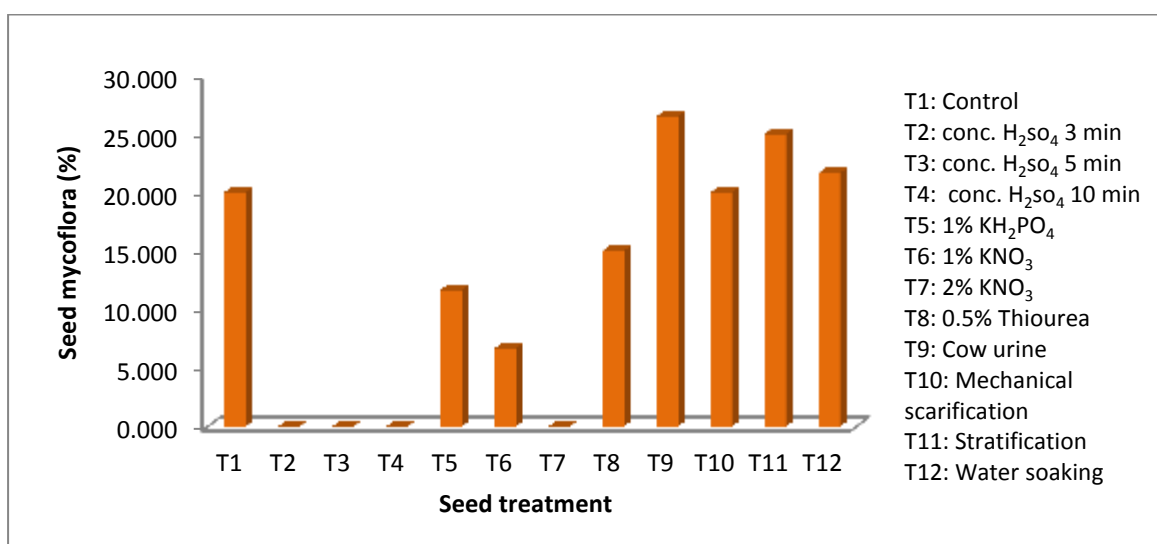


Fig 23 Effect of seed treatments on seed mycoflora (%)

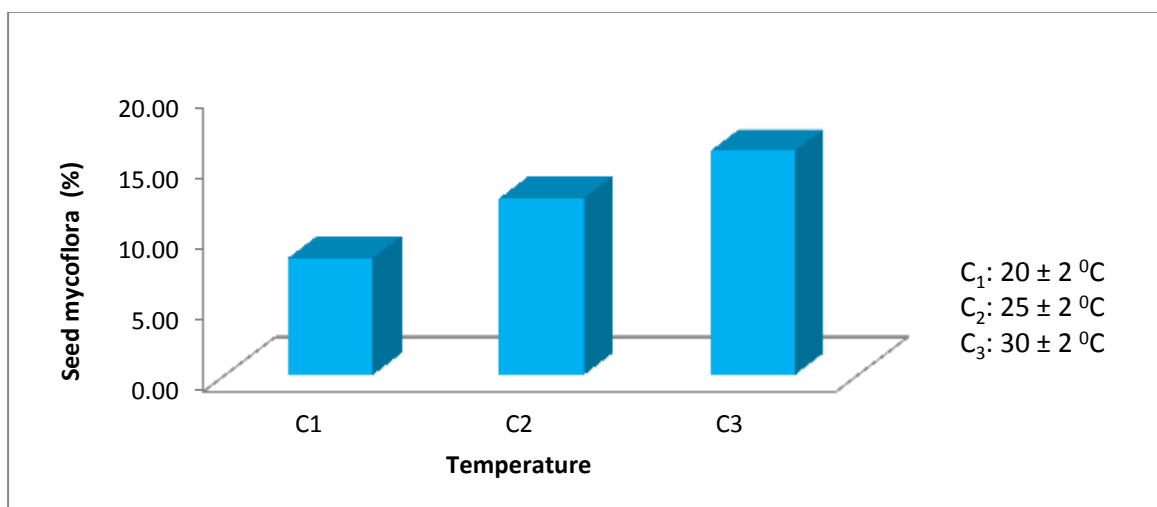


Fig 24 Effect of temperature on seed mycoflora (%)

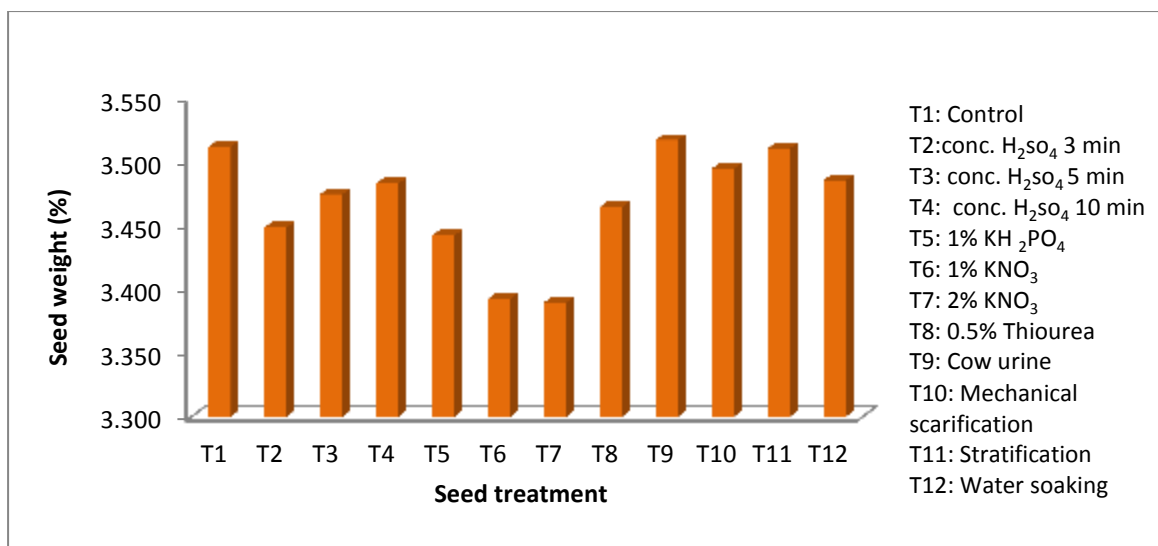


Fig 25 Effect of seed treatments on seed weight (g)

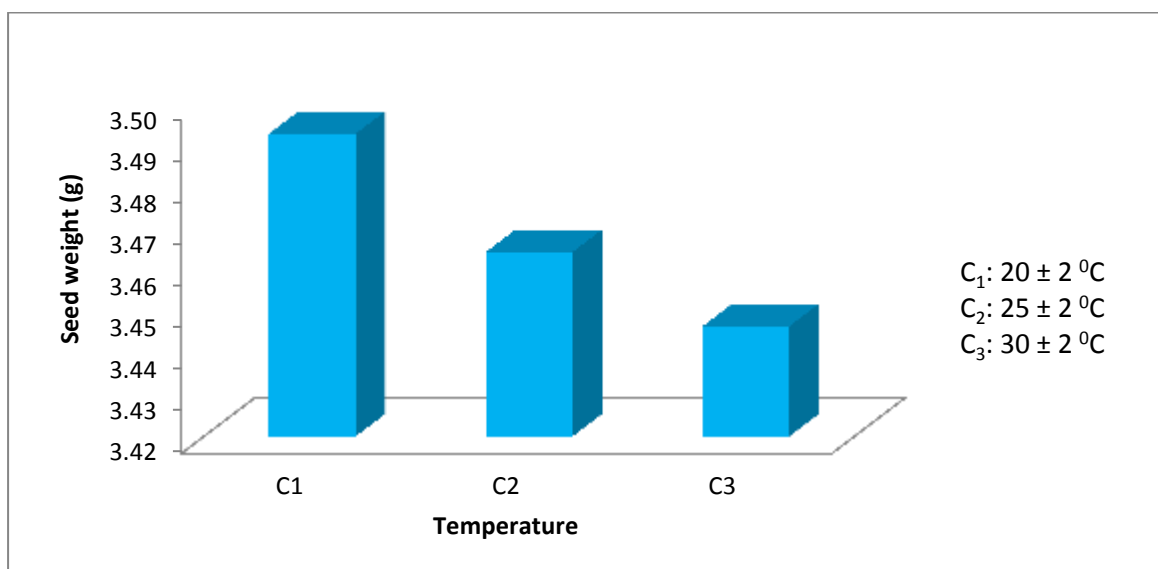


Fig 26 Effect of temperature on seed weight (g)